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ART. I.—*Contributions to Meteorology, being results derived from an examination of the Observations of the United States Signal Service, and from other sources;* by ELIAS LOOMIS, Professor of Natural Philosophy in Yale College. Sixth paper. With plates I, II and III.

[Read before the National Academy of Sciences, Philadelphia, Oct. 18, 1876.]

Period of unusual heat in June, 1873.

IN June, 1873, an unusually high temperature prevailed throughout a large portion of the United States. At most of the Signal Service stations the thermometer rose above 90° during some part of the month, and at several of the stations there were more than ten days on which the thermometer rose as high as 90°. In the following table, column 1st shows the

Temperature of 90° *in June*, 1873.

Stations.	Latitude.	Elevation. ft.	Cases.	Stations.	Latitude.	Elevation. ft.	Cases.
Fort Sully	44° 39′	1687	17	St. Paul	44° 53′	794	5
Indianola	28 32	25	13	Boston	42 21	77	3
San Antonio	29 25	600	13	Baltimore	39 18	45	2
Mobile	30 42	41	12	Chicago	41 52	657	2
Denver	39 44	5135	11	New York	40 42	165	2
Keokuk	40 23	584	11	Toledo	41 40	649	2
Montgomery	32 22	250	11	Cleveland	41 30	682	1
Washington	38 53	105	10	Fort Garry	49 52	654	1
LaCrosse	43 48	686	8	New Haven	41 17	107	1
Cairo	37 0	352	7	Oswego	42 28	291	1
Louisville	38 18	496	7	Lexington, Ky.	38 8	1083	0
Cincinnati	39 6	614	6	Montreal	45 30	187	0
Leavenworth	39 19	813	6	Morgantown	39 40	991	0
Breckenridge	46 16	966	5	Rochester	43 8	584	0
Cheyenne	41 12	6058	5	Toronto	43 39	342	0
Omaha	41 16	1045	5				

names of the stations at which observations were made with self-registering thermometers; column 2d shows the latitude of the stations; column 3d shows their elevation above the sea, expressed in feet; and column 4th shows the number of days on which the thermometer rose as high as 90°.

The observations at Denver and Cheyenne indicate that on an elevated plateau the extreme heat of summer is at least as great as it is at the level of the sea in the same latitude; while the observations at Lexington and Morgantown show that an elevation of a few hundred feet above the surrounding country has a sensible effect in moderating the extremes of heat. The observations in the vicinity of the Great Lakes as well as those near the Ocean show that large bodies of water have a decided influence in moderating the extremes of temperature.

The stations at which the thermometer rose above 90° in more than three cases are all inland stations; and it is noticeable that at certain northern stations the heat was more intense than at any of the southern stations. At Fort Sully the thermometer rose to 108°; on seven days it rose above 100°; and on twelve days it rose as high as 95°. At Denver the thermometer rose

Observations of the thermometer at $4^h\ 35^m$ P. M., *June* 15–26, 1873.

Stations.	Mean temp. June.	Above or Below the Mean Temperature.										
		June 15.	June 16.	June 17.	June 18.	June 19.	June 20.	June 21.	June 22.	June 23.	June 24.	June 25.	June 26.
Portland, Or.	62°	+ 1	+ 5	− 2	− 1	+ 6	+ 2	− 1	− 3	+ 1	+ 1	+ 6	+ 8
San Francisco	59	+ 3	+ 7	+ 7	+ 7	+ 6	+ 1	+ 2	+ 8	+ 8	− 1	0	+15
San Diego	65	0	+ 4	+ 5	+ 2	+ 2	+ 5	+ 3	+ 2	+ 2	+ 2	+ 3	+ 5
Corinne	69	+19	+20	+14	+18	+18	+20	+13	− 8	− 5	+ 8	+14	+16
Virginia City	56	+28	+24	+12	+ 5	+13	+18	+ 3	−18	− 1	+ 9	+ 4	+ 6
Fort Benton	63	+30	+15	+18	+ 4	+ 9	+13	+ 6	− 4	+ 5	+10	− 8	+ 1
Santa Fe	69	+ 6	+ 3	+ 8	+13	+11	0	+12	+11	+10	+ 4	+12	+15
Denver	69	+12	+19	+21	+26	+13	+23	+21	+23	+15	+23	+18	+24
Cheyenne	65	+14	+22	+21	+21	+10	+25	+20	+11	− 4	+23	+24	+23
Fort Sully	70	+22	+24	+27	0	+12	+24	+25	+20	+ 8	+19	+31	+24
Yankton	71	+12	+14	+14	+10	+ 7	+14	+15	+11	+ 5	+14	+18	+20
Pembina	63	+14	+10	+13	+11	+12	+10	+ 6	+ 4	+ 8	+17	+16	+19
Fort Garry	63	+12	+20	+17	+ 2	+10	+14	+11	+ 4	+10	+10	+19	+19
Indianola	82	+ 6	− 6	− 2	+ 1	+ 5	+ 3	+ 5	+ 3	+ 3	+ 5	+ 3	+ 6
Breckenridge	65	+15	+19	+25	+25	+12	+12	+17	+13	+ 9	+19	+25	+28
Omaha	73	+13	+14	+13	+16	+ 9	+12	+ 7	+ 2	+ 8	+15	+16	+18
Leavenworth	76	+10	+11	+10	+12	+14	+10	+12	+ 7	+ 7	+10	+15	+16
Galveston	82	+ 2	− 7	− 3	− 2	+ 5	+ 7	+ 6	+ 6	+ 7	+ 6	+ 8	+ 8
Shreveport	81	− 2	− 4	+ 2	+ 2	+ 8	+ 9	− 3	+ 6	+ 7	+ 7	+11	+ 9
St. Paul	68	+17	+14	+21	+22	+11	+16	+22	+ 8	+17	+17	+ 5	+22
Duluth	58	+28	+ 2	− 2	+23	+23	+20	− 8	− 8	− 1	− 2	0	− 2
Fort Gibson	79	− 4	+ 6	+ 6	+ 6	+ 5	+ 6	+ 6	+ 7	+ 9	+10	+11	+14
Keokuk	75	+16	+11	+12	+13	+16	+10	+15	+12	+13	+18	+18	+16
LaCrosse	70	+18	+11	+19	+20	+10	+13	+16	+13	+18	+20	+17	+21
Vicksburg	81	− 5	− 3	+ 2	− 1	+ 3	+ 9	+10	+ 9	+10	+11	+ 9	+12

TABLE—continued.

Stations.	Mean temp. June.	Above or Below the Mean Temperature.											
		June 15.	June 16.	June 17.	June 18.	June 19.	June 20.	June 21.	June 22.	June 23.	June 24.	June 25.	June 26.
Davenport	73°	+13	+17	+14	+16	+13	+11	+10	+13	+16	+19	+18	+17
St. Louis	76	+12	+ 7	− 2	+16	+13	+ 2	+ 8	+15	+16	+16	+17	+13
Memphis	79	+ 8	0	− 4	+ 8	+ 6	+12	+12	+14	+13	+15	− 6	+11
New Orleans	80	− 3	+ 5	+ 1	− 1	+ 6	+ 8	+ 9	+ 8	+ 6	+ 3	+ 7	+ 6
Cairo	77	+10	+ 4	+ 6	+ 6	+ 7	+ 9	+10	+12	+12	+14	+ 3	+13
Mobile	80	+ 8	− 4	+ 1	− 4	+10	+ 4	+ 3	+14	0	+12	+13	+ 2
Milwaukee	65	+12	+ 2	− 4	+26	+23	+18	+10	+ 2	+27	+ 4	+ 2	+ 9
Chicago	68	+11	0	0	+19	+22	+ 6	+17	+13	+22	− 2	0	+ 7
Marquette	58	+ 5	+ 1	+ 5	+ 7	+25	+20	− 8	− 4	+11	+ 3	+10	+16
Escanaba	60	+ 8	0	+ 6	+14	+25	+21	+ 4	+ 3	+ 3	+11	+11	+16
Nashville	79	+ 7	− 4	+ 5	+ 7	+ 5	+10	+ 9	+13	− 3	+12	+14	0
Montgomery	80	+ 7	− 1	− 6	+ 6	+12	+13	+10	+12	+14	0	+13	+ 8
Grand Haven	65	+11	+ 7	+ 5	+15	+ 9	+ 3	+12	+13	+15	+12	+22	+14
Indianapolis	75	+11	+ 2	+11	+14	+15	+11	+11	+14	+18	+18	+10	+19
Louisville	77	+10	+10	+ 9	+13	+ 9	+ 7	+10	+ 9	+16	+14	− 4	+10
Cincinnati	76	+10	+15	+ 6	+ 5	+11	+11	+13	+13	+17	+18	+11	+13
Knoxville	74	+11	− 1	+ 9	+ 9	+10	+ 9	+17	+14	+11	+15	+17	+ 7
Toledo	72	+12	+16	+ 4	+15	+18	+11	+12	+14	−11	− 5	+ 2	+11
Alpena	60	0	+14	− 7	+28	+20	+15	− 2	− 4	− 5	+ 2	+ 2	+ 5
Detroit	68	+12	+19	+ 5	+15	+22	+13	+17	− 1	+16	+11	+22	+12
Lake City	79	+ 6	+ 7	+11	+13	+15	+12	+ 8	− 3	+ 5	+10	+10	− 2
Punta Rassa	80	+ 7	+ 7	+ 8	+ 9	+ 9	+ 7	+ 5	+ 4	+ 3	− 7	+ 9	+ 6
Augusta	79	+ 7	+10	+12	+12	+15	+12	+15	+ 9	+10	+12	+ 8	− 4
Key West	83	+ 5	+ 5	+ 5	+ 4	+ 5	+ 5	+ 6	+ 6	+ 6	+ 5	+ 4	+ 3
Jacksonville	80	+ 6	+ 9	+11	+13	+14	+16	− 1	+ 5	+ 6	+ 9	+ 7	+ 1
Cleveland	69	+ 7	+16	+ 5	+13	+20	+10	+10	+11	+13	+ 9	+ 6	+11
Saugeen	60	+ 8	+ 1	− 3	+20	+19	+ 2	− 1	+12	+ 4	+25	+15	+12
Port Stanley	65	+ 9	+12	+ 6	+ 8	+13	+13	+10	− 3	+ 7	− 4	+12	+ 8
Savannah	80	+ 7	+11	+12	+13	+14	+12	+ 4	+ 6	+ 3	+ 8	+10	− 6
Port Dover	65	+ 6	+20	+ 6	+ 5	+ 9	+12	+ 3	− 6	+13	+ 2	+18	+16
Charleston	79	+ 6	+ 9	+11	+11	+ 8	+11	+ 5	+ 4	+ 4	+10	+ 2	− 3
Pittsburgh	72	+11	+ 1	+11	+13	+17	+12	+13	+20	+19	+12	+ 3	+ 9
Toronto	63	+15	+17	+ 2	+ 6	+17	+ 9	+17	− 1	− 2	+ 6	+ 7	+ 4
Lynchburg	74	− 1	+13	− 7	+ 7	+15	+16	+ 9	+13	− 1	− 1	+12	+ 4
Buffalo	65	+ 5	+ 7	+ 8	+ 6	+ 9	+11	+ 7	− 3	+14	+ 5	+16	+11
Wilmington	77	+ 4	+11	+ 4	+16	+17	+15	+13	+11	+12	+16	− 1	+ 3
Rochester	66	+11	+ 4	+ 3	+16	+20	+ 7	+10	− 5	+ 7	+ 1	+12	+16
Washington	75	− 2	+15	+16	+17	+18	+19	+11	+20	+ 4	+ 4	− 1	+10
Baltimore	75	− 5	+13	+13	+12	+18	+19	+13	+14	− 4	+ 2	+ 1	+ 6
Oswego	64	+13	+ 9	+ 5	+15	+18	− 3	+ 4	+ 3	+12	+10	+10	+23
Kingston	63	+ 7	+ 4	− 2	+ 5	+ 8	+13	+11	+ 6	+ 8	+12	+18	+14
Norfolk	76	−12	+13	+10	+12	+16	+20	+10	+16	+14	+14	− 9	+ 2
Philadelphia	72	+ 1	+13	+13	+12	+18	+18	+11	+ 8	− 7	− 8	0	+ 5
Cape May	67	− 4	+ 2	+ 6	+ 2	+ 6	+22	+13	+ 8	+ 2	+ 1	+ 1	+ 2
New York	69	+ 1	+13	+13	+ 3	+19	+20	+12	0	− 5	− 8	0	+ 5
Montreal	66	+ 6	+ 7	+ 1	+ 1	+ 4	+ 4	− 5	+ 1	+ 4	+ 7	+ 6	+ 7
Burlington	66	+13	+13	+ 1	+ 6	+14	+ 9	− 6	+ 5	+11	+11	+17	+18
New London	65	+ 3	+12	+15	+ 5	+23	+22	+14	+ 5	0	− 2	+ 2	+10
Mt. Washington	43	+ 4	+ 8	− 6	+ 1	+10	+ 6	− 9	− 7	+ 3	+ 5	+12	+14
Quebec	64	+10	+10	0	−17	− 7	− 1	− 5	+ 5	+11	+13	+18	+15
Boston	67	+15	+22	+15	+14	+24	+18	+ 8	+ 2	+ 7	+ 6	+ 9	+21
Portland, Me.	62	+ 3	+15	+14	+ 1	+ 3	+21	+ 5	+ 3	+ 4	+10	+12	+ 8
Eastport	55	+ 3	0	+12	+10	− 6	− 1	0	+ 7	+16	+ 5	+13	+ 9

to 99°, and on five days it rose as high as 95°. At Indianola the highest temperature was 97°·5, and only twice did the thermometer rise as high as 95°. At San Antonio the highest temperature was 96°, and only once did the thermometer rise as high as 95°. At Mobile the highest temperature was 95°, and these are the highest temperatures reported at any of the southern stations. We thus see that at Fort Sully and Denver the thermometer rose higher than it did at any of the southern stations.

If we consider simply the height of the thermometer above the mean temperature of the month, we find that by far the most remarkable cases occurred at stations north of latitude 40°. The preceding table exhibits the observed changes of temperature from June 15 to June 26. Column second shows the mean temperature of June at the stations named in column first, and the succeeding columns show the difference between the mean temperature of the month and the temperature observed each day at $4^h\ 35^m$ P. M. At this hour the temperature at most of the stations is about 8° above the mean temperature of the day, so that nearly all the numbers given in this table should be diminished by about 8° in order to show the elevation above the mean temperature at the hour of observation; and at a few of the stations a still larger correction is required.

In order to exhibit more clearly the conclusions to be derived from the numbers in the preceding table I have prepared the following summary, in which column second shows for each day at what station the temperature rose *most* above the mean for the month; column third shows how much the thermometer rose above the mean; column fourth shows the state of the barometer at the given station, and column fifth shows the lowest barometer observed on the given day at any of the stations.

Temperatures most above the mean.

Date.	Stations.	Temperature.	Barom.	Lowest barom.
June 12	Fort Benton	+19°	29·97	29·64
13	Fort Sully	+21	29·68	29·68
14	Breckenridge	+19	29·59	29·46
15	Fort Benton	+30	29·80	29·63
16	Virginia City	+24	29·67	29·64
"	Fort Sully	+24	29·69	29·64
17	Fort Sully	+27	29·52	29·38
18	Alpena	+28	29·54	29·26
19	Escanaba	+25	29·52	29·49
"	Marquette	+25	29·53	29·49
20	Cheyenne	+25	29·90	29·41
21	Fort Sully	+25	29·46	29·46
22	Denver	+23	29·61	29·30
23	Milwaukee	+27	29·77	29·57
24	Saugeen	+25	30·06	29·62
"	Denver	+23	29·87	29·62
25	Fort Sully	+31	29·52	29·52
26	Breckenridge	+28	29·68	29·68

We see from this table that the stations at which the thermometer rose most above the mean were all north of lat. 39°, and they are all situated between the Rocky Mountains and the meridian of 81° west of Greenwich. We also see that a high temperature was generally accompanied by a barometer below the mean; the average pressure shown in column fourth being 29·70. Column fifth shows that on each day there was a considerable barometric depression in some part of the United States and the center of this depression was always north of lat. 40°, and the region of greatest heat was always within the influence of the area of depressed barometer. In four instances the station which showed the greatest rise of temperature showed also the greatest depression of the barometer.

In order to exhibit more clearly the form and position of these heated areas I have prepared Chart I, which shows the thermic isabnormals for June 18th, at 4^h 35^m, P. M., the curves being drawn at intervals of 5°.

From this chart we perceive that near the Gulf of Mexico, and also near the northeast and northwest angles of the United States, the temperature was below the mean for the month of June, but in every other portion of the United States the temperature was above the mean for the month. In order to determine how much the mean temperature at the hour of observation exceeds the mean temperature of the month, I have compared the observations of maxima and minima temperatures at all the Signal Service stations as far as they have been published in the annual Reports. I have taken the mean of the maxima of temperature for the month of June at each station, and also the mean of the minima. The difference between these two months I call the mean diurnal oscillation of the thermometer. I have made this comparison for each of the years 1873, 4, and 5. The following table shows all the Signal Service stations at which the mean diurnal oscillation exceeds 22°, and also all those stations at which the oscillation is less than 15°. Column second shows the mean diurnal oscillation for the month of June at the stations named in column first; column third shows the number of years of observation; column fourth shows the height of the station above the sea; column fifth shows the annual rain-fall at each station; and column sixth shows the rain-fall in 1873, from June 12th–26th inclusive.

Since we have a series of hourly observations of the thermometer at Philadelphia and Toronto we can compute the correction to be applied on account of the hour of observation at each of the preceding stations, if we assume that the correction at different stations is proportioned to the entire daily oscillation. We thus find that at the hour of 4·35 P. M., Washington

Diurnal oscillation of temperature in June.

Stations.	Oscillation	Years.	Elevation. ft.	Annual rain-fall.	Rain-fall 15 days.
Colorado Springs	33°·7	2	5935	13·69	
Denver	32·2	3	5135	13·99	0·02
Cheyenne	31·6	3	6058	8·60	0·22
Santa Fe	30·7	2	6862	13·36	0·02
Dodge City	28·2	1	2482	6·49	
Fort Sully	26·7	3	1687	12·16	0·34
Virginia City	25·7	3	5510	16·43	0·28
Salt Lake City	25·4	2	4350	17·93	0·05
Fort Garry	25·3	3	654	14·48	1·09
Ottawa	24·7	2	250	29·33	
North Platte	24·6	1	2846	13·64	
Corsicana	24·3	1	447	25·42	
Pittsburgh	23·5	1	955	37·53	0·80
Stayner	23·5	1	714	28·26	
Bismark	23·3	1	1677	21·09	
Wytheville	23·3	2	2294	44·15	
Shreveport	22·9	2	228	49·60	3·89
Pembina	22·8	2	790	12·99	1·37
Island of St. Paul	7·0	2		55·85	
Cape Hatteras	8·8	1	7	64·38	
Cape Rozier	9·7	1	39	33·81	
Key West	10·6	3	17	37·60	
Cape May	11·0	1	14	46·87	
Mt. Washington,	11·4	3	6285	66·47	
New Orleans	11·9	2	56	61·46	
San Diego	12·0	2	62	9·16	
Wood's Hole	12·1	2	25	39·36	
Galveston	12·9	2	40	46·66	
Charleston	13·0	2	61	44·18	
San Francisco	13·4	2	60	20·20	
Indianola	13·6	3	25	41·98	
Atlantic City	13·8	2	23	36·16	
Punta Rassa	13·8	2	17	53·42	
Buffalo	14·8	2	662	34·36	
Kitty Hawk	14·9	1	22	45·02	

time, the temperature exceeds the mean of the month by the following quantities:

Correction for hour of observation.

Stations.	Correc.	Stations.	Correc.	Stations.	Correc.
Denver	13°	Virginia City	10°	Saugeen	8°
Cheyenne	13	Breckenridge	9	Escanaba	7
Fort Sully	10	Alpena	8	Marquette	7
Fort Benton	10	Milwaukee	8		

Applying these corrections to the numbers given on page 4 we find that on June 15th the thermometer at Fort Benton rose 20° above the mean temperature of that station at the hour of observation; on the 18th at Alpena it also rose 20°, and on the 25th at Fort Sully it rose 21° above the mean temperature at the hour of observation. We are then required to explain how

the thermometer should rise 20° above the mean temperature of the hour and place.

The accompanying Chart, Plate II, shows the isobaric curves for the same date as the temperature curves of Plate I. We perceive that throughout the entire United States, with the exception of the Pacific coast and the vicinity of the Gulf of Mexico, the pressure of the atmosphere was less than 30 inches; and in Minnesota the pressure was 29·30. This barometric minimum would lead us to look for southerly winds throughout the valley of the Mississippi. The actual direction of the winds observed is shown by arrows on Chart I. The following table shows the number of stations at which the wind blew from each of the eight principal points of the compass.

Direction of the winds, June 18th, 4h 45m P. M.

Wind.	No. of Stations.	Wind.	No. of Stations.
North	3	South	20
Northeast	2	Southwest	27
East	4	West	7
Southeast	7	Northwest	7

We see that at 54 stations the wind blew from some southern quarter, and at only 12 stations did it blow from a northern quarter. The following are the stations in question:

North wind at Cleveland, Mobile and Santa Fe.

Northeast wind at Duluth and Yankton.

Northwest wind at Eastport, Fort Garry, Fort Sully, Mt. Washington, Norfolk, Oswego and Pembina.

At three of these stations, viz: Cleveland, Duluth and Oswego, the northerly wind was probably the result of the cooler air of the Lakes moving toward the warmer land. Three of the stations, viz: Fort Sully, Fort Garry and Pembina, were situated on the north side of the area which was most heated; and two other stations, viz: Eastport and Mt. Washington were on the extreme eastern border of the heated area. At Mobile the velocity of the wind was only *one mile* per hour; at Norfolk and Yankton it was four miles; and at Santa Fe five miles per hour.

We thus see that throughout the entire heated area (with a few trifling exceptions which are easily explained) the movement of the atmosphere was from the south. This general movement from the south had prevailed for more than 24 hours with an average velocity of about ten miles per hour, which should cause a rise in the thermometer of from 6 to 10 degrees in the vicinity of the western Lakes; that is, this cause seems to be sufficient to account for nearly (if not fully) half of the rise actually observed.

A considerable part of the remaining rise may probably be ascribed to the accumulated effect of the sun's radiation for many successive days without the interference of northerly winds. As early as the 10th of June there was a large rise of the thermometer at Fort Benton and Virginia City, and this was maintained pretty steadily until the 17th. This heated air drifted slowly to the eastward and on the 18th reached the neighborhood of the Great Lakes.

The great diurnal oscillation of temperature observed at Denver and its vicinity, probably depends somewhat upon the configuration of the surrounding country, but the most important circumstance is the extreme dryness of the climate of this region. In a country where the annual rain-fall is small, and the surface of the earth becomes very dry, the earth readily absorbs the rays of sun, and there is little evaporation to counteract their heating effect. The thermometer therefore during the day time rises higher than it would if the earth were moist and covered with green grass. At night, on the contrary, the heat is rapidly dissipated, and there is no vapor to be condensed, which by the latent heat liberated would counteract the effects of radiation. Thus during the night the thermometer sinks lower than it would in a moist atmosphere.

The same phenomenon is noticed in other countries which have a dry climate. At Madrid in Spain the mean diurnal oscillation of the thermometer is much greater than in most parts of Europe. The following table shows the difference between the mean of the daily maxima and the daily minima at Madrid for the months of June and July during a period of eight years. The fourth column shows the highest temperature observed during each year, and the fifth column shows the rain-fall of each year expressed in English inches.

Range of thermometer at Madrid, Spain. Height, 1939 *feet.*

Years.	June.	July.	Highest temp.	Annual rain-fall.
1866	25°·2 Fahr.	29°·3 F.	101°·1 F.	19·82
1867	30·8	31·5	100·8	15·04
1868	31·1	30·2	102·7	11·83
1869	30·6	32·2	105·1	11·04
1870	32·0	32·8	104·7	12·81
1871	27·0	32·6	108·3	16·22
1872	32·8	33·1	106·3	15·30
1873	27·9	32·8	104·6	15·07
Mean	29·7	31·8	104·2	14·64

The last column in the table on page 6 shows that in June, 1873, an unusual drought prevailed throughout Colorado, Wyoming and Montana. In consequence of this extreme dry-

ness, the heating effect of the sun's rays was greatly increased, and this cause combined with the prevalent southerly winds will probably explain the extreme heat observed in that region. The heat experienced in the neighborhood of the Great Lakes may be ascribed partly to the same causes operating in that locality, and partly to a mass of heated air drifted eastward from the dryer regions of the West.

The remarkable heat recorded at Fort Sully and mentioned on page 2, seems to indicate some peculiarity of that locality. In order to discover the nature of this peculiarity I have collected all the cases in which a temperature of 100° and upward is mentioned in the annual Reports of the Signal Service for 1873, 4, and 5. The following table shows the number of such cases for each year. For the year 1875 the observations include only the first six months of the year. The mark (*) shows that no observations of self-registering thermometers were received from the stations indicated.

Number of cases of a temperature of 100° *Fahr.*

	1873.	1874.	1875.		1873.	1874.	1875.
Fort Gibson	*	21	0	Louisville	0	3	0
Shreveport	*	3	18	Denver	0	2	0
Fort Sully	20	13	2	Dodge City	*	0	2
Leavenworth	0	12	0	Keokuk	1	2	0
Nashville	*	7	0	LaCrosse	*	2	0
Omaha	0	6	0	Augusta, Ga.	*	1	0
Cairo	0	4	0	Cincinnati	0	1	0
Corsicana	*	0	4	Indianola	0	1	0
Memphis	*	4	0	Jacksonville	*	1	0
Montgomery	0	4	0	Mobile	0	1	0
St. Louis	*	4	0	Washington	1	1	0
Dubuque	*	3	0	Yankton	*	1	0

These observations show that the thermometer seldom rises to 100° in the vicinity of the Atlantic Ocean, the Gulf of Mexico, or the Great Lakes. Cases of extreme heat are of most frequent occurrence between the Mississippi River and the Rocky Mountains. They are the effect of the dryness of the soil and of the atmosphere in that region; and they serve to intensify the dryness from which they result. If we compare the high temperatures observed at Fort Sully with the observations at neighboring stations, we shall perceive that they are altogether exceptional. The first column of the following table shows a series of stations on the Missouri River; column second shows the latitude of the stations; column third shows their elevation (in feet) above the ocean; and column fifth shows the number of cases in which the thermometer, in 1873, 4, and 5, was observed to rise as high as 100°.

Temperature of 100° *Fahr.*

	Latitude.	Elevation.	Cases.
Leavenworth	39° 19′	813	12
Omaha	41 16	1045	6
Yankton	42 45	1296	1
Fort Sully	44 39	1687	35
Bismark	46 48	1677	0

The first three stations, together with the fifth, show a steady decline in the intensity of the heat as we advance northward; but Fort Sully shows temperatures much greater than occur at stations several hundred miles southward. At this station the meteorological instruments are located within the walls of the fort, and the thermometers are probably influenced by heat reflected from dry sand, and stone walls. This seems to be the most probable explanation of the excessive heat reported at Fort Sully.

Rain-areas—their form, movements, distribution, etc.

In order to investigate the form of rain-areas; the laws which govern their movements, and their relations to the isobaric curves I selected all those cases during a period of fifteen months (Sept. 1872 to Nov. 1873) in which at least two inches of rain fell at one station in eight hours. These cases were then divided into two classes, one containing the stations south of latitude 36°, and the other containing the stations north of latitude 36°. The following table exhibits all the cases which occurred at the southern stations. Column first contains the number of reference, column second shows the day and hour of observation (the numeral one denotes the 7.35 A. M. observation; two denotes 4.35 P. M., and three denotes 11 P. M.); column third shows the station at which the greatest rain-fall was observed; column fourth shows the precise amount of the rain: column fifth shows the height of the barometer at the same station; column sixth shows the direction and force of the wind at the last *preceding* observation; column seventh shows the direction and force of the wind at the date given in column second; column eighth shows whether the direction of the winds at the neighboring stations indicated a cycloidal or inward motion; column ninth shows whether there was any local depression of the barometer; and column tenth shows whether there was a high or a low barometer on the north side of the given station.

For a large number of these cases I have drawn upon maps of the United States, the curves of equal rain-fall for each fourth of an inch. These curves show that when there is only one principal center of precipitation, the form of the rain-area is nearly circular, and its diameter varies from 350 to 750 miles.

Rain-fall of two inches at Stations south of lat. 36°.

No.	Date.	Station.	Rain. In.	Bar.	Wind at prev. ob.	Wind at date.	Cycloidal motion.	Local dep'n.	On N. side.
	1872.								
1	Sept. 10–2	Jacksonville.	2·42	30·09	S.E. 3	N. 2	probable	none	low
2	11–2	Montgomery.	2·00	29·93	E. 4	S.E. 2	decided	slight	low
3	25–1	Shreveport.	2·05	30·11	W. 5	N.E. 14	decided	none	low
4	26–1	Wilmington.	2·09	30·05	Calm	S. 4	decided	none	high
5	30–1	Charleston.	2·07	30·01	S.W. 6	N.E. 6	decided	none	low
6	Oct. 9–2	New Orleans.	2·19	29·96	E. 8	E. 8	decided	slight	high
7	22–2	Punta Rassa.	2·06	29·92	E. 23	S.E. 15	decided	slight	high
8	22–3	Jacksonville.	2·43	29·99	N.E. 12	E. 13	decided	slight	high
9	23–1	Jacksonville.	2·05	29·83	E. 13	W. 1	very dec'd	decided	high
10	29–2	Shreveport.	2·24	29·95	Calm	S.W. 10	not dec'd	slight	low
11	Nov. 6–1	Galveston.	3·75	29·76	E. 2	S.E. 28	decided	decided	low
12	6–3	Montgomery.	2·73	29·95	E. 3	S.E. 22	decided	slight	high
13	8–1	New Orleans.	3·15	29·85	N.E. 16	N. 18	decided	slight	high
14	8–2	Mobile.	2·04	29·84	N.E. 8	E. 12	decided	decided	high
15	Dec. 10–1	Indianola.	2·14	29·86	N.E. 35	N. 40	decided	slight	high
16	18–2	New Orleans.	2·20	30·08	S.W. 6	N.E. 8	decided	none	high
	1873.								
17	Jan. 5–1	Lake City.	2·00	29·89	S.E. 4	S.E. 7	decided	slight	low
18	16–1	New Orleans.	2·01	29·32	S. 8	N.W. 12	decided	slight	low
19	Mar. 29–1	Lake City.	2·00	29·97	N.E. 8	N.W. 12	decided	slight	low
20	April 29–2	Savannah.	2·15	29·99	S. 10	Calm	slight	slight	low
21	May 1–2	Montgomery.	3·05	29·87	S.E. 4	S.E. 4	slight	slight	low
22	5–3	New Orleans.	2·40	29·81	E. 12	E. 16	decided	decided	low
23	6–1	Mobile.	2·34	29·85	N.E. 6	N.E. 16	decided	decided	low
24	18–2	Galveston.	2·00	29·77	S.E. 16	N.E. 22	decided	decided	low
25	19–2	Mobile.	2·47	29·99	N.W. 1	N. 8	not dec'd	none	low
26	20–2	New Orleans.	2·08	29·92	N. 3	S.E. 12	slight	slight	low
27	June 1–1	Key West.	2·05	30·00	N.E. 2	S.W. 6	decided	slight	high
28	8–2	Mobile.	2·10	30·01	S.W. 2	W. 1	decided	small	low
29	10–3	Memphis.	2·68	29·98	S.E. 8	N.E. 4	decided	small	
30	July 21–2	Mobile	2·30	30·07	N. 4	S. 8	decided	none	low
31	22–2	Mobile.	3·14	30·18	N.E. 16	E. 16	slight	none	low
32	Aug. 2–2	Punta Rassa.	3·32	30·06	N.E. 4	N. 2	decided	none	low
33	6–1	Charleston.	2·05	30·23	N.E. 4	N.E. 8	none	none	high
34	8–3	Vicksburg.	2·00	30·08	Calm	Calm	not dec'd	none	high
35	9–2	New Orleans.	2·03	30·02	E. 12	E. 10	doubtful	not dec'd	low
36	17–3	Punta Rassa.	2·69	30·11	S.W. 13	E. 5	not dec'd	none	high
37	20–2	Jacksonville.	3·72	30·06	S.E. 4	E. 20	decided	none	high
38	21–1	Galveston.	3·67	29·95	E. 5	Calm	decided	slight	low
39	21–2	Mobile.	2·04	29·96	N.E. 4	E. 8	decided	slight	low
40	30–2	Indianola.	2·16	30·20	S.E. 20	N. 6	not dec'd	none	low
41	Sept. 13–2	Galveston.	2·95	29·97	N.E. 9	N.E. 14	not dec'd	not dec'd	high
42	18–1	Mobile.	2·35	29·90	N.E. 7	E. 12	decided	small	low
43	18–2	Mobile.	2·73	29·90	E. 12	E. 12	decided	small	high
44	20–1	Wilmington.	2·38	29·82	N.E. 8	N.W. 14	decided	small	low
45	26–2	Indianola.	2·96	29·85	S.E. 20	S. 14	doubtful	not dec'd	low
46	Oct. 3–1	Jacksonville.	2·74	30·04	N. 12	N.W. 4	doubtful	not dec'd	high
47	Nov. 1–1	Havana.	2·80	30·11	N.E. 11	N.E. 10	doubtful	small	high
48	2–3	Galveston.	3·50	30·05	S. 16	S. 12	decided	small	high
49	5–2	Montgomery.	2·97	30·06	Calm	S.E. 1	decided	small	high
50	17–2	Havana.	2·88	29·73	S.W. 5	N.W. 6	probable	doubtful	low
51	22–3	Shreveport.	2·16	29·80	N. 5.	S.E. 5	decided	decided	low
52	29–1	Havana.	2·10	30·18	N.W. 6	N.E. 4	probable	doubtful	high

These excessive rain-falls are not of long continuance, but their exact duration cannot be determined from the observations. In two cases (viz., Nos. 8 and 42) over two inches of rain fell in two successive periods of eight hours at the same station; and in a few other cases these great rain-falls were followed during the next eight hours by a fall of one inch or more, either at the same station, or at a station a little to the eastward. The following table shows all the cases in which any of these heavy rain-falls were followed by one inch of rain at a neighboring station during a succeeding period of eight hours.

Cases of heavy rain continuing more than eight hours.

Date.	Rain. In.	Station.	Date.	Rain. In.	Station.	Date.	Rain. In.	Station.	Date.	Rain. In.	Station.
1872.											
Sept. 11–2	2·00	Montgomery.	11–3	1·10	Lake City.	23–1	2·05	Jacksonville.	23–2	1·58	Charleston.
Oct. 22–2	2·06	Punta Rassa.	22–3	2·43	Jacksonville.	6–3	2·73	Montgomery.			
Nov. 6–1	3·75	Galveston.	6–2	1·88	Galveston.						
Nov. 8–1	3·15	New Orleans.	8–2	2·04	Mobile.						
Dec. 10–1	2·14	Indianola.	10–2	1·03	Galveston.						
1873.											
Jan. 5–1	2·00	Lake City.	5–2	1·19	Norfolk.						
May 1–2	3·05	Montgomery.	1–3	1·80	New Orleans.						
May 5–3	2·40	New Orleans.	6–1	2·34	Mobile.	6–2	1·11	Montgomery.	6–3	1·64	Jacksonville.
May 20–2	2·08	New Orleans.	20–3	1·21	New Orleans.						
Aug. 21–1	3·67	Galveston.	21–2	2·04	Mobile.						
Sept. 18–1	2·35	Mobile.	18–2	2·73	Mobile.						
Oct. 3–1	2·74	Jacksonville.	3–2	1·25	Jacksonville.						

In three cases we find three successive periods of heavy rain-fall, and in two cases we find four such periods, indicating a duration of heavy rain for thirty-two hours. We conclude therefore that great rain-falls do not generally continue over eight hours, and very rarely do they continue for twenty-four hours, either as experienced at one station, or in succession at different places.

These heavy rain-falls appear to result from the unstable condition of the different strata of the atmosphere. When the atmosphere near the earth's surface becomes unusually heated it tends to ascend; and if this atmosphere contains a large amount of aqueous vapor, its specific gravity is thereby diminished and it has a much stronger tendency to ascend. It thus frequently happens that the atmosphere is in a state of unstable equilibrium, and a slight cause is sufficient to determine a strong upward movement of the surface air, resulting in a precipitation of vapor. When air in this unstable condition has a movement along the earth's surface, a slight inequality of the surface may be sufficient to determine an upward movement at that point. We should therefore conclude that when a current of warm and moist air flows in from the ocean and impinges upon the land, a strong upward movement accompanied by heavy precipitation must frequently result. This conclusion is confirmed by a comparison of the preceding observations. Among the stations of the Signal Service south of latitude 36°, there are twelve stations situated on the Atlantic coast or the Gulf of Mexico. At these stations during a period of fifteen months the average number of great rain-falls (two inches in eight hours) has been 3·6. Among the stations of the signal service south of latitude 36°, there are also five inland stations, whose average distance from the coast is 200 miles, and during the same period the average number of great rain-falls at these stations has been 1·8; that is, near the coast great rain-falls occur *twice* as frequently as they do at stations in the interior at a distance of 200 miles from the coast.

Whenever a strong upward movement of the air commences, there must be a general tendency of the surrounding air toward this point, and the air must circulate from right to left as it does in great storms. Hence every great rain-storm should be accompanied by an inward and cycloidal motion of the air. In about two-thirds of the preceding cases there is decided evidence of the existence of such a cycloidal movement, and in most of the remaining cases there are some indications of such a movement. If observations could be obtained from a sufficient number of stations, it is believed that some degree of cycloidal motion would be indicated in every case of heavy rain-fall.

The depression of the barometer attending these rain-falls was generally small, nevertheless in several cases it was quite

appreciable. At the time of the observations shown in the table on page 11, the average height of the barometer was less than thirty inches, while the mean height throughout the year at the same stations was nearly 30·10 inches. That a cycloidal movement of the air should produce so little depression of the barometer is due to three circumstances; first, the small velocity of the wind (averaging less than nine miles per hour); second, the small area of the cycloidal movement (generally about 500 miles in diameter), and third, the proximity of the stations to the equator. According to Ferrel's formula any great barometric depression requires a strong wind; the cycloidal movement must extend over a large area; and the depression of the barometer is proportioned to the sine of the latitude of the place. In about half of the preceding cases there was an area of low barometer prevailing in the northern portion of the United States, and about as frequently, there was an area of high barometer on the northern side of the station. These different conditions appear to be about equally favorable to heavy rain-falls.

The distribution of these fifty-two cases by seasons was as follows:

Spring, 8; Summer, 14; Autumn, 14 and 12; Winter, 4.

We thus see that great rain-falls are most frequent when the heating effect of the sun's rays is greatest and the atmosphere contains the greatest amount of vapor.

The distribution of these cases according to the hours of the day was as follows:

At the 7.35 A. M. obs.	19	cases.
4.35 P. M.	25	"
11.00 P. M.	8	"

The intervals between the observations, which for convenience I have called eight hours, are in fact unequal. Making, however, due allowance for inequality of intervals, it seems clear that in the United States, south of latitude 36°, heavy rain-falls are less frequent from 4.35 P. M. to 11 P. M., than during the remainder of the day. If we knew the precise time of beginning and end of each rain-fall we might determine the precise hour of maximum and of minimum frequency of heavy rain-falls.

On Plate III are shown the curves of equal rain-fall for June 10, 1873, being No. 29 of the table on page 11. The outer curve shows the extreme limits of the rain-area; the next curve shows the limits of a rain-fall of one inch; and the inner curve shows the limits of a rain-fall of two inches. The arrows show the direction of the wind as reported at 4.35 P. M., which is presumed to have been about the time of the commencement of the rain-fall. There was a center of low pressure (29·71)

near Lake Ontario, and a center of high pressure (30·16) near Charleston, S. C. As the result of this unequal pressure, southerly winds generally prevailed throughout the Southern States. A northwest current had however set in from the neighborhood of Minnesota, and this wind had reached St. Louis and Fort Gibson. The temperature at St. Louis was 71°, while at Memphis it was 87°. This cooler wind from the northwest probably flowed under the southeast wind from Memphis, causing it suddenly to ascend, and thus produced a rapid precipitation of vapor.

Rain-fall of two inches at stations north of lat. 36°.

The following table contains all the cases in which at least two inches of rain fell in eight hours at any of the northern stations from Sept., 1872, to Nov., 1873. Column 1st contains the number of reference; column 2d shows the day and hour of observation; column 3d shows the station at which the

Rain-fall of two inches at stations north of lat. 36°.

No.	Date.	Station.	Rain. In.	Bar.	Wind at prev. ob.	Wind at date.	Rain center from Low. Direction.	Rain center from Low. Distance.	Low bar.
	1872.								
1	Sept. 23–2	Grand Haven.	2·89	29·77	S.E. 6	S.E. 7	East	660	29·35
2	26–2	Mt. Washington.	2·27	30·14	S.W. 43	S.W. 32	S. 80 E.	733	29·59
3	28–3	Chicago.	2·02	29·35	N.E. 22	N.E. 11	*	00	29·35
4	Oct. 25–1	Norfolk.	3·41	29·95	E. 13	S.E. 8	*	00	29·95
5	26–1	Philadelphia.	2·09	29·78	E. 20	S.W. 12	S. 54 E.	137	29·74
6	Nov. 7–1	New York.	2·50	29·68	S.E. 4	N.W. 10	S. 65 E.	777	29·33
7	Dec. 26–1	Norfolk.	2·08	29·46	N.E. 21	N. 20	*	00	29·46
	1873.								
8	Jan. 5–2	Philadelphia.	2·18	29·61	N.E. 20	N.E. 8	S. 58 E.	218	29·45
9	May 1–1	Nashville.	2·20	29·73	S.E. 4	E. 25	S. 64 E.	420	29·58
10	9–2	New London.	2·35	30·06	N.E. 4	N.E. 26	N. 83 E.	696	29·62
11	22–1	Lynchburg.	2·10	30·00	N.E. 4	Calm	S. 80 E.	886	29·45
12	June 9–3	St. Louis.	2·93	29·87	S. 8	S. 5	S. 21 W.	420	29·70
13	22–3	St. Paul.	2·28	29·55	S.E. 13	S.E. 18	N. 70 E.	185	29·43
14	23–1	St. Paul.	2·30	29·57	S.E. 18	S.W. 2	S. 70 E.	88	29·52
15	July 2–1	Indianapolis.	2·04	29·94	S.E. 12	S.W. 3	S. 5 E.	218	29·77
16	16–1	Marquette.	2·10	29·94	Calm	S. 8	N. 88 E.	549	29·47
17	16–2	Fort Garry.	2·45	29·49	E. 10	S. 5	*	00	29·49
18	17–3	Buffalo.	2·00	29·64	S.W. 14	S.W 7	*	00	29·64
19	26–1	Buffalo.	2·20	29·83	S.E. 4	Calm	N. 56 E.	160	29·81
20	27–2	Washington.	2·12	30·11	S. 10	W. 8	S. 63 E.	1175	29·72
21	27–3	Philadelphia.	2·03	30·16	N.W. 8	S. 8	S. 64 E.	1140	29·85
22	Aug. 13–1	Philadelphia.	2·31	30·04	E. 16	N.E. 12	N. 70 E.	360	29·92
23	13–2	Philadelphia.	2·17	29·97	N.E. 12	N.E. 22	N. 40 E.	350	29·85
24	13–3	Baltimore.	3·26	29·86	N.E. 12	N.E. 12	North	40	29·86
25	14–1	Breckenridge.	2·05	29·86	S. 16	S.E. 16	N. 53 E.	187	29·71
26	25–2	Erie.	2·00	29·82	S.E. 1	W. 4	North	312	29·70
27	Sept. 10–1	Norfolk.	2·05	30·16	Calm	E. 4	N. 22 E.	668	29·97
28	19–3	Mt. Washington.	2·20	29·86	S.W. 24	W. 12	North	202	29·59
29	Oct. 7–1	Portland, Me.	2·02	29·40	N. 12	N. 20	*	00	29·40
30	19–3	New London.	2·25	29·80	S.E. 2	S.E. 24	N. 34 E.	329	29·52
31	Nov. 24–2	New London.	2·80	29·30	S.E. 14	N. 1	S. 61 W.	90	29·27

greatest rain-fall was observed; column 4th shows the precise amount of the rain-fall; column 5th shows the height of the barometer at the same station; column 6th shows the direction and force of the wind at the last *preceding* observation; column 7th shows the direction and force of the wind at the date given in column 2d; column 8th shows the direction of the rain center from the nearest center of low pressure; column 9th shows the distance of the rain center from the center of low pressure, expressed in miles; and column 10th shows the height of the barometer at the center of low pressure.

In all of these cases there was an area of low pressure within the limits of the United States, and generally the place of greatest rain-fall was within the cycloidal movement attending this low pressure. The distance of the rain center from the center of low pressure was however very variable.

In 16	cases	the distance was	less than 250 miles.
6	"	"	between 250 and 500 miles.
5	"	"	between 500 and 750 miles.
4	"	"	over 750 miles.

In the two cases of July 27th, the low pressure was so inconsiderable and remote as to exert very little influence upon the winds at Philadelphia and Washington.

We thus see that north of lat. 36° great rain-falls generally occur within 250 miles of a center of low pressure, and almost invariably on the east side of the low center. In two of the preceding cases (Nos. 12 and 31) the rain center is stated to be west of the low center. But it should be remembered that the rain-fall occurred during the eight hours preceding the date of the barometric observation. The middle of the rain-fall may be regarded as corresponding to a date four hours preceding the barometric observation, and during these four hours, the low center generally advances eastward 100 miles. We may therefore conclude that in No. 31 the principal rain-fall occurred when the rain center was east of the low center. In No. 12 the principal rain-fall occurred on the southwest side of the low center, but the barometric gradient was only one-tenth of an inch to 350 miles. The rain center occurs as frequently in the N.E. quarter from the low center as it does in the S.E. quarter.

The four cases in which the rain center was more than 750 miles distant from the nearest center of low pressure were Nos. 6, 11, 20 and 21. In No. 6 a distinct local cyclone formed near New York, accompanied by a slight local depression of the barometer, which had the effect of urging the low center eastward with extraordinary velocity. From 7.35 A.M. to 4.35 P.M., that is, in nine hours, the low center advanced eastward 900 miles, although the greatest velocity of the wind, recorded

anywhere near the path of the storm, was thirty-eight miles per hour (on Mt. Washington), indicating that the progress of the low center was not due wholly to the transfer of air from west to east, but rather to a *diminution* of the pressure on the east side of the low, and an *increase* of the pressure on its western side.

In No. 11 Lynchburg was somewhat nearer to a center of high pressure than of low pressure. There are indications that a small local cyclone formed about Lynchburg, but the stations of observation are too few to show this conclusively.

In Nos. 20 and 21 the rain center was much nearer to a center of high pressure than of low pressure. At 4.35 P. M. a distinct local cyclone was shown about Baltimore, Washington, and Cape May, but the cyclonic area was of small diameter and its effect upon the barometer was scarcely appreciable.

We thus see that great rain-falls may occur under the influence of an area of high pressure as well as of low pressure, and when they occur at a great distance from a low center, they are generally accompanied by a distinct local cyclonic movement of the atmosphere.

Of the thirty-one cases included in the preceding table, fifteen occurred on the Atlantic coast, and the number of stations of observation upon the coast was eleven; which shows an average of 1·37 to each station. For the remainder of the United States there were sixteen cases, and the number of stations was fifty-nine, showing an average of 0·27 to each station. Thus we see that north of lat. 36° near the Atlantic coast, great rain-falls are *five times* as frequent as in other parts of the United States in the same latitude. The frequency of heavy rain-falls in the neighborhood of the great lakes is not sensibly greater than at inland stations quite distant from the lakes.

The distribution of these 31 cases by seasons was as follows:

Spring 3; summer 15; autumn 6 and 5; winter 2.

Showing a predominance of great rain-falls in summer even more decided than at the southern stations.

The distribution of these cases according to the hours of the day was as follows: 7·35 A. M., 14 cases; 4·35 P. M., 9 cases; 11 P. M., 8 cases.

If we correct these numbers for the inequality of the time intervals, there is still an excess of cases for the morning hour of observation.

The following table shows all the cases in which any of these heavy rain-falls were followed by at least one inch of rain during a succeeding period of eight hours.

At the southern stations, out of fifty-two cases of heavy rain there were twelve cases in which heavy rain continued through two periods of eight hours; at the northern stations out of

thirty-one cases there were thirteen which continued through two periods, indicating that heavy rains are of longer duration at the northern stations than they are at the southern. In two instances the center of the rain area apparently moved westward. Thus on the morning of July 16th, the center of the rain area was at Marquette, which was more than 500 miles eastward of the center of low pressure; but in the afternoon the center of the rain area coincided with the center of low pressure; that is, the center of the rain area moved toward the northwest. So also on the morning of May 1st, the center of the rain area was more than 400 miles eastward of the center of low pressure; in the afternoon the center of the rain area extended southward; and during the evening it extended toward the southwest.

Cases of heavy rain continuing more than eight hours.

Date.	Rain. In.	Station.	Date.	Rain. In.	Station.	Date.	Rain. In.	Station.
1872.								
Sept. 26–2	2·27	Mt. Washington.	26–3	1·20	Mt. Washington.			
28–3	2·02	Chicago.	29–1	1·31	Grand Haven.			
Oct. 25–1	3·41	Norfolk.	25–2	1·45	New York.			
Nov. 7–1	2·50	New York.	7–2	1·49	New London.			
1873.								
May 1–1	2·20	Nashville.	1–2	3·05	Montgomery.	1–3	1·80	New Orleans.
June 9–3	2·93	St. Louis.	10–1	1·07	St. Louis.	10–2	1·50	Indianapolis.
22–3	2·28	St. Paul.	23–1	2·30	St. Paul.			
July 16–1	2·10	Marquette.	16–2	2·45	Fort Garry.			
17–3	2·00	Buffalo.	18–1	1·05	Mt. Washington.			
27–2	2·12	Washington.	27–3	2·03	Philadelphia.			
Aug. 13–1	2·31	Philadelphia.	13–2	2·17	Philadelphia.	13–3	3·26	Baltimore.
Oct. 7–1	2·02	Portland, Me.	7–2	1·60	Eastport.			
19–3	2·25	New London.	20–1	1·96	Burlington.	20–2	1·38	Mt. Washington.

The average direction and force of the wind during these cases of heavy rain-fall both for the southern and northern stations was as follows:

		Direction.	Force.
South of latitude 36°.	At previous obs.	N. 79° E.	8·1
	at date,	N. 75° E.	9·9
North of latitude 36°.	At previous obs.	S. 69° E.	11·8
	at date,	S. 39° E.	11·3

We thus see that both at the northern and southern stations heavy rains are generally accompanied by easterly winds. At the northern stations southeast winds are most prevalent, while at the southern stations northeast winds are most prevalent. At the southern stations there are but eleven cases in which east winds are not reported either at date or at the preceding observation. These exceptions are Nos. 4, 10, 18, 20, 25, 28, 30, 34, 46, 48 and 50. In four of these cases the force of the wind was reported 0; in two of them it was reported as

one mile per hour; in two cases it was four miles per hour; in one case it was five miles; in one case eight miles and in one case twelve miles per hour. We thus see that during a heavy rain-fall, the wind either blows from some eastern quarter, or its velocity is almost invariably small.

At the northern stations there are but eight cases in which east winds are not reported either at date or at the preceding observation. These exceptions are Nos. 2, 12, 16, 18, 20, 21, 28 and 29. Two of these cases occurred on the summit of Mt. Washington; in one of the remaining cases the velocity of the wind was 0; in one it was five miles per hour; in one it was seven miles; in two it was eight miles; and in one it was twelve miles per hour. We thus see that at the northern stations as well as at the southern, during a heavy rain-fall the wind blows from some eastern quarter, or its velocity is almost invariably small.

On Plate III are shown the curves of equal rain-fall for Sept. 23, 1872, being No. 1 of the table on page 15. The outer curve shows the extreme limits of the rain area and the other curves show the limits of a rain fall of one inch and of two inches. The arrows show the direction of the wind at 7 A. M., which was previous to the middle of the rain fall. There was a center of low pressure (29·35) near Omaha, which was about west of the center of the rain area and distant from it 660 miles. Near the Atlantic coast there was a belt of high pressure (30·25). The result of this unequal pressure was a general prevalence of southeast winds throughout a large part of the Mississippi valley. Northerly winds commenced blowing from the neighborhood of Lakes Superior and Huron, being the result of a lower temperature and a higher pressure. This colder wind from the north probably flowed under the southeast wind which had been blowing over Lake Michigan and produced that strong upward movement of the air which was followed by excessive rain at Grand Haven and Milwaukee.

In a large number of the cases in the table on page 15 the observations show that a southeast wind at certain stations was opposed by a westerly or northerly wind at other stations. This opposition or interference of winds generally results in a cycloidal movement, and the observations clearly indicate such a movement in nearly all of the cases in the table on page 15. When the rain area was remote from the center of low pressure this cycloidal movement was local and limited to a small area and did not generally exert a decided influence upon the isobaric curves.

In preparing the materials for this article I have been assisted by Mr. Edward S. Cowles, Ph.D., a graduate of Yale College of the class of 1873.

ART. II.—*On Some Points in Connection with Vegetation:* by DR. J. H. GILBERT.*

THE subject of vegetation is such a very wide one, and might be treated of in so many different ways, that it seems desirable to state at the outset what is the scope, and what are the limits, of the discussion which I propose to bring before you. I propose, then, to confine attention almost exclusively to the question of the *Sources of the nitrogen of vegetation in general, and of agricultural production in particular.* I propose further to treat of this subject mainly in the aspects in which it has forced itself upon the attention of Mr. Lawes and myself during the now thirty-three years of our agricultural investigations; and, also, in so far as it illustrates, and is illustrated by, the objects contributed by Mr. Lawes to the Exhibition around us.

Before entering upon the special subject matter of my discourse, I must claim the indulgence of those present, who are already well acquainted with the main facts of the chemistry of vegetation, while I call attention, very briefly, to some rather elementary matters, with a view of rendering what has to follow the more intelligible to any who may be less fully informed on the subject.

When a vegetable substance is burnt—as a familiar instance, let us say tobacco, for example—the greater part of it is dissipated, but there remains a white ash. The ashes of crude or unripe vegetable substances are found on analysis to contain most, or all, of the following constituents, namely:—

Oxide of iron, oxide of manganese, lime, magnesia, potass, soda, phosphoric acid, sulphuric acid, chlorine, and silica.

Rarer substances than these are also sometimes found. Now, much has of late years been established in regard to the occurrence, and the offices, of some of these substances in plants; but I do not propose to touch upon the questions herein involved. It will suffice further to say in regard to these incombustible, or "mineral" constituents, that the ash of one and the same description of plant, growing on different soils, may, so long as it is in the growing or immature state, differ very much in composition. Again, the ashes of different species, growing on the same soil, will differ very widely in the proportion of their several constituents. But it is found that the nearer we approach to the elaboration of the final products of the plant —the seed, for example—the more fixed is the composition of ash of such products of one and the same species. In other

* An address delivered at South Kensington, in the Chemical Section of the Science Conferences, by Dr. J. H. Gilbert, F.R.S., F.L.S., F.C.S.

words, there is very little variation in the composition of the ash of one and the same description of seed, or other final product, provided it be evenly and perfectly matured. This fact alone, independently of all that has been established of late years in regard to the office or function, so to speak, of individual mineral constituents of plants, would be sufficient to indicate the essentialness of such constituents for healthy growth; and it is obvious that they must be provided *within the soil.*

But now as to the combustible constituents—the carbon, the hydrogen, the oxygen, and the nitrogen. Leaving out of consideration such exceptional cases as those brought to light in Mr. Darwin's beautiful investigation on insectivorous plants, and also the sources of the organic substance of fungi, and perhaps of some forced horticultural productions, it may be stated, that the source of the carbon of vegetation generally is the carbonic acid existing in very small proportion, but in large actual amount, in the atmosphere; that the source of the hydrogen is water; and that the source of the oxygen may be either that in carbonic acid, or that in water. With regard to the nitrogen the case is, however, by no means so simple. Not that there are no questions still open for investigation in regard to the assimilation by plants of their incombustible or mineral constituents, or of their carbon, their hydrogen, and their oxygen; but those relating to the sources, and to the assimilation, of their nitrogon, are not only in many respects of more importance, but seem to involve greater difficulties in their solution.

What, then, are the sources of the nitrogen of vegetation? Are they the same for all descriptions of plants? Are they to be sought entirely in the soil? or entirely in the atmosphere? or partly in the one, and partly in the other?

Amount of nitrogen carried down by atmospheric precipitation.—As the combined nitrogen coming down from the atmosphere in rain, hail, snow, mists, fog, and dew, does undoubtedly contribute to the annual yield of nitrogen in our crops, let us first briefly consider what is known as to the amount of it annually so coming down over a given area of the earth's surface; and as we are here discussing the subject in England, I will adopt the English pound as the unit of weight, and the English acre as the unit of area. The following table shows the amount of nitrogen coming down as ammonia and nitric acid in the total rain, hail, snow, and some of the minor deposits, during the years 1853, 1855, and 1856, at Rothamsted (Herts), the nitric acid being in all cases determined by Mr. Way, and the ammonia in some cases by him, and in others by ourselves:—

TABLE I.—*Combined Nitrogen in Rain and Minor Aqueous Deposits at Rothamsted.*

	Nitrogen per acre, per annum, lbs.			
	1853.	1855.	1856.	Mean.
As ammonia	5·67	5·86	7·85	6·46
As nitric acid	(not determined)	0·77	0·73	0·75
Total		6·63	8·58	7·21

Numerous determinations of the ammonia and nitric acid in rain, and the other aqueous deposits, have been made in various parts of France and Germany, some in the vicinity of towns, and some in the open country. Of the latter, which are the most to our purpose, it may be stated that those of Boussingault at Liebfrauenberg, in Alsace, generally indicate a larger proportion of the nitrogen existing as nitric acid, and less as ammonia than our own; but, upon the whole, the observations in the two widely separated localities mutually confirm one another. Of the results of others, in other localities, some show about the same amount of combined nitrogen so deposited as our own, some, however, much more, and some much less, than ours; but the determinations on the Continent generally show a higher proportion of the total combined nitrogen to exist as nitrates than those in this country. It may be added, that numerous determinations of the combined nitrogen in rain, dew, etc., collected at Rothamsted, have much more recently been made by Professor Frankland, and his results, which are published in the "Sixth Report of the Rivers Pollution Commission," are substantially confirmatory of the earlier determinations, summarized in the foregoing Table, but upon the whole they indicate lower amounts. Lastly, M. Marié-Davy determined the ammonia in the rain, etc., collected at the Meteorological Observatory at Montsouris, Paris, during the last six months of 1875; and the amount of ammonia so coming down, even within the walls of Paris, represented only 5·25 lbs. of combined nitrogen per acre, or only 10·5 lbs. per acre, per annum. M. Marié-Davy did not make a complete series of determinations of the nitric acid in the meteoric waters, but his initiative results agree with the experiments of others in showing the amount of combined nitrogen to be comparatively small.

Thus, the determinations hitherto made of the amount of combined nitrogen coming down in the measured aqueous deposits from the atmosphere, do not justify us in assuming that the quantity available from that source will exceed eight or ten lbs. per acre, per annum, in the open country, in Western Europe. It should be observed, however, that the amount of ammonia especially is very much greater in a given volume

of the minor aqueous deposits than it is in rain; and there can be little doubt that there would be more ammonia deposited from them within the pores of a given area of soil, than on an equal area of the non-porous even surface of a rain gauge. How much, however, would thus be available to the vegetation of a given area beyond that determined in the collected and measured aqueous deposits, we have not the means of estimating with any certainty. On the other hand, numerous independent determinations, by both Dr. Voelcker and Dr. Frankland, of the nitric acid in the drainage-water collected from land at Rothamsted which had been many years unmanured, lead to the conclusion that there may be a considerable annual loss of nitrogen by the soil in that way.

Amount of nitrogen derived by crops of different kinds when grown without manure.—The next point to consider is, what is the amount of nitrogen annually obtained over a given area, in different crops, when they are grown without any supply of it in manure. This point may be illustrated by the results obtained in the field experiments on Mr. Lawes' farm at Rothamsted, which have now been in progress for about a third

TABLE II.—*Yield of Nitrogen per acre, per annum, in Wheat, Barley, and Root Crops, at Rothamsted.*

Crop. &c.	Condition of Manuring, &c.		Duration of Experiment.	Average Nitrogen per acre, per annum.
				lbs.
Wheat.	Unmanured		8 yrs. 1844-'51	25·2
			12 yrs. 1852-'63	22·6
			12 yrs. 1864-'75	15·9
			24 yrs. 1852-'75	19·3
			32 yrs. 1844-'75	20·7
	Complex Mineral Manure		12 yrs. 1852-'63	27·0
			12 yrs. 1864-'75	17·2
			24 yrs. 1852-'75	22·1
Barley.	Unmanured		12 yrs. 1852-'63	22·0
			12 yrs. 1864-'75	14·6
			24 yrs. 1852-'75	18·3
	Complex Mineral Manure		12 yrs. 1852-'63	26·0
			12 yrs. 1864-'75	18·8
			24 yrs. 1852-'75	22·4
Root Crops.	Complex Mineral Manure.	Turnips	8 yrs. 1845-'52	42·0
		Barley	3 yrs. 1853-'55	24·3
		Turnips	15 yrs. 1856-'70*	18·5
		Sugar-beet	5 yrs. 1871-'75	13·1
		Total	31 yrs. 1845-'75	26·8

* Thirteen years' crop—two years failed.

of a century. Table II shows the yield of nitrogen per acre, per annum, in wheat, in barley, and in root crops, each grown for many years in succession on the same land, either without any manure, or with only a complex mineral manure, that is supplying no nitrogen.

Bearing in mind what has been said as to the amount of combined nitrogen known to be annually deposited from the atmosphere, the figures in Table II have great interest and significance. Thus, over a period of thirty-two years, the wheat has yielded an average of 20·7 lbs. of nitrogen, per acre, per annum, without manure. But if we look at the quantities yielded during the first eight, the next twelve, and the last twelve years of that period, it is seen that there has been a gradual, but at the same time a considerable decline in the annual yield. From this it would appear probable that the nitrogen of the soil derived from previous accumulations, is being gradually reduced. Whether or not the whole of the excess of yield over that available from the rain, and other measured aqueous deposits from the atmosphere, is due to previous accumulations within the soil, and is therefore inducing a gradual exhaustion of its stock of nitrogen to that extent, we have not conclusive evidence to show. Determinations of nitrogen in samples of the soil taken at different times during the course of the experiments do, indeed, show an appreciable reduction. It is probable, however, that a part of the excess of yield is due to condensation of ammonia within the pores of the soil, beyond that which would be deposited in rain, and in the dew and other minor deposits condensed on the non-porous even surface of a rain-gauge, as already referred to.

Excluding the first eight years of the growth of wheat, it is seen that while over the next twenty-four years, 1852–1875, the wheat yielded 19·3 lbs. of nitrogen, per acre, per annum; the barley yielded an average of 18·3 lbs. over the same period. Again, during the first twelve of the twenty-four years, the wheat yielded 22·6 lbs., and the barley 22 lbs.; while, during the second twelve years, the yield in wheat was reduced to 15·9, and that in the barley to 14·6 lbs. The similarity in the yield of nitrogen over the same periods in these two closely allied crops, growing in different fields, is very striking, though, upon the whole, the indication is that the autumn-sown wheat has accumulated more than the spring-sown barley.

It is next to be observed that the annual use of a complex mineral manure has but very slightly increased the yield of nitrogen in either of these gramineous crops; and it is probable that the increased yield, such as it is, is derived from the previous accumulations within the soil, and not from atmospheric sources.

To sum up the evidence in regard to the sources of the nitrogen of these two typical gramineous plants, when none of it is supplied to them by manure, though it is not conclusively shown whence the whole of it is derived, it would at any rate appear probable, that it may be accounted for by the combined nitrogen coming down in rain and in the other measured aqueous deposits from the atmosphere, by the condensation of the ammonia of the air within the pores of the soil, and by the previous accumulations within the soil.

Let us now consider what is the yield of nitrogen by plants of other natural families, and first of all by certain so-called "root-crops"—turnips of the natural order Cruciferæ, and sugar beet of the order Chenopodiaceæ. On this point we have the experience of thirty-one years, excepting that during three of those years barley was grown without any manure in order to equalise the condition of the land as far as possible before re-arranging the manuring, and during two other years the turnips failed and there was no crop.

It should be premised that when root-crops are grown without manure of any kind, there is after a few years scarcely any produce at all; and hence the results recorded in the table are those obtained by the use of mineral manures, but without any supply of nitrogen. It is seen that during the first eight years of turnips, there was an average yield of 42 lbs. of nitrogen per acre, per annum. During the next three years barley yielded 24·3 lbs. annually. During the next fifteen years, thirteen with Swedish turnips, and two without any crop, there was a yield of 18·5 lbs. per acre annually. During the last five years sugar-beet yielded 13·1 lbs. per acre, per annum. Lastly, over the whole thirty-one years, during which there were three crops of barley, two years without any crop, twenty-one years of turnips, and five of sugar-beet, the average annual yield was 26·8 lbs. of nitrogen.

Here, then, we have a reduction to less than one-third during the later compared with the earlier years, and to a lower point than even with either wheat or barley; though, during the whole period, the annual yield is higher than with either of the two gramineous crops. It may be mentioned that we have other experimental evidence showing that the so-called "root-crops" exhaust at any rate the superficial layers of the soil of their available supplies of nitrogen, more completely than perhaps any other crop. It may further be added that the surface soil has shown during recent years a lower percentage of nitrogen than that of any of the other experimental fields. We have fair grounds for concluding, therefore, that if in the cases of the wheat and the barley the nitrogen yielded beyond that retained by the soil from the direct measurable aqueous deposits,

together with that condensed within the pores of the soil from the atmosphere, be derived from previous accumulations within the soil, so also may the excess of yield by the so-called "root-crops" be accounted for.

We now come to the consideration of the yield of nitrogen when plants of the *leguminous* family are separately grown, or when they, and plants of some other families, are grown in alternation, or in association, with the Gramineæ. Table III shows the results obtained with beans, and with clover; with clover and barley grown in alternation; and with turnips, barley, clover or beans, and wheat, grown in an actual course of rotation.

TABLE III.—*Yield of Nitrogen per acre, per annum in Beans, in Red Clover, and in Rotation.*

Crops, &c.	Conditions of Manuring, &c.	Duration of Experiment.	Average Nitrogen per acre, per annum.
			lbs.
Beans	Unmanured	12 yrs. 1847-'58	48·1
		12 yrs. 1859-'70(*)	14·6
		24 yrs. 1847-'70	31·3
	Complex Mineral Manure	12 yrs. 1847-'58	61·5
		12 yrs. 1859-'70(*)	29·5
		24 yrs. 1847-'70	45·5
Clover	Unmanured	22 yrs. 1849-'70(†)	30·5
	Complex Mineral Manure	22 yrs. 1849-'70(†)	39·8
Barley Clover	Unmanured	1 yr. 1873	37·3
		1 yr. 1873	151·3
Barley	Unmanured—After Barley	1 yr. 1874	39·1
	Unmanured—After Clover	1 yr. 1874	69 4
	Barley after Clover more than after Barley		30·3
Rotation 7 Courses	1 Turnips, 2 Barley, 3 Clover or Beans, 4 Wheat — Unmanured	28 yrs. 1848-'75	36·8
	1 Turnips, 2 Barley, 3 Clover or Beans, 4 Wheat — Superphosphate	28 yrs. 1847-'75	45·2

Referring first to the results obtained with beans the table shows that without manure there was an annual yield over the first twelve years, 1847–1858, of 48·1 lbs. of nitrogen. Over the next twelve years, 1859–1870, it was reduced to 14·6 lbs. per acre, per annum. Still, over the whole period of twenty-four years, we have an annual yield of 31·3 lbs., or more than one and a half time as much as in either wheat or barley.

(*) Nine years Beans, one year Wheat, two years fallow.
(†) Six years Clover, one year Wheat, three years Barley, twelve years fallow.

In the case of wheat and barley it was seen that a mixed mineral manure increased the yield of nitrogen to a very small degree only. Not so in the case of the leguminous crop, beans. During the first twelve years a complex mineral manure, containing a large amount of potass—I call attention to this fact because we have abundant evidence that it is the potass chiefly that is effective—gave 61·5 lbs. of nitrogen per acre per annum against 48·1 lbs. obtained over the same period without manure. During the next twelve years, the potass manure gave 29·5 lbs. against scarcely half as much, or 14·6 lbs. without the potass manure. And finally, during the whole period of twenty-four years, the potass manure has given 45·5 lbs. of nitrogen per acre, per annum, against 31·3 lbs., or only about two thirds as much, without manure; and we have more than twice as much yielded by a potass manure over a period of twenty-four years with beans than with either wheat or barley.

Before calling attention to the figures relating to another leguminous crop—red clover—it should be mentioned that leguminous crops generally are, and clover in particular is, extremely sensitive to adverse climatal circumstances; but clover is pre eminently sensitive to soil conditions also. Indeed, it is a fact well recognized in agriculture, that few soils can be relied upon to grow a good crop of clover oftener than once in about eight years; and many soils will not yield it so frequently. It will not excite surprise, therefore, that in attempting to grow clover year after year on the same land, we have only succeeded in getting any crops, and some of those poor ones, in six years over a period of twenty-two. Indeed, the plant failed seven times out of eight during the winter and spring succeeding the sowing of the seed; when, in some cases a crop of wheat or barley was taken, and in others the land was left fallow. Hence, over a period of twenty-two years we have had only six years of clover, one of wheat, three of barley, and twelve of fallow. Still, the annual yield of nitrogen over the twenty-two years was 30·5 lbs. without any manure, and 39·8 lbs., or nearly one third more, by mineral manure containing potass. Unfavorable as was this experiment in an agricultural point of view, still it is seen that the influence of the interpolation of this leguminous crop has greatly increased the yield of nitrogen compared with that obtained in either wheat or barley grown continuously; and that, unlike the result with those crops, a potass manure has here again, as with beans, greatly increased the yield.

Without attempting for the moment to discuss the probable source or sources of this greatly increased yield of nitrogen by leguminous as compared with gramineous crops, I will simply here remark in passing that we have no evidence leading to the

conclusion that this increased assimilation is at the expense of the nitrogen existing at any rate in the upper layers of the soil. In fact, such initiative results as we have relating to the nitrogen in the soil of the experimental bean field, would rather lead to the conclusion that the better the crop has grown, and the more nitrogen it has assimilated, the richer rather than the poorer in nitrogen (as indicated by the soda-lime method) has the surface soil become. To this point, however, we shall have to recur presently; but in the meantime let us first refer to the yield of nitrogen in other cases in which leguminous crops have been interpolated with others.

It is, indeed, well known that the growth and removal of a highly nitrogenous leguminous crop is one of the best possible preparations for the growth of a gramineous corn crop, which characteristically requires nitrogenous manuring. A striking illustration of this apparent anomaly is afforded in the results next in order recorded in Table III.

After the growth of six corn crops in succession by artificial manures alone, barley was grown without manure in 1873 on one portion of the same land; and on another portion clover was grown. It is calculated that there were taken off in the barley 37·3 lbs. of nitrogen, and in the three cuttings of clover 151·3 lbs. Yet, in the next year, 1874, barley succeeding the barley gave 39·1 lbs., and barley succeeding the clover gave 69·4 lbs. of nitrogen; or 30·3 lbs. more after the removal of 151·3 lbs. in clover than after the removal of 37·3 lbs. in barley. Nor was this remarkable result to be explained by either accident or error. For, determinations of nitrogen in four separately taken samples of the soil, in the mixture of the four, and in the mixture of six others, taken from each plot, and at different depths, all concurred in showing an appreciably higher percentage of nitrogen, especially in the surface soil, nine inches deep, of the land from which the clover had been removed than in that from which the barley had been taken; and this was so, although, in every case, all visible vegetable debris had been carefully picked out. Here, then, the surface soil at any rate was positively enriched in nitrogen (determinable by soda-lime) by the growth and removal of a very highly nitrogenous crop. It may be mentioned that Dr. Voelcker has obtained results of a similar character.

The results next to be considered are those obtained in an actual four-course rotation of crops—namely, turnips, barley, clover or beans, and wheat. The experiments have been conducted through seven such courses; that is to say, over a period of twenty-eight years. One portion of the land, the results relating to which are given in the table, has been entirely unmanured during the whole of that period, and the other has

received super-phosphate of lime alone, once every four years —that is to say, for the turnips commencing each course; but it has received no other manure throughout the twenty-eight years, either mineral or nitrogenous.

Under these conditions—that is with a turnip crop and a leguminous crop interpolated with two gramineous crops—we have, without manure of any kind, an average of 36·8 lbs. of nitrogen yielded per acre, per annum; or not far from twice as much as was obtained with either of those cereal crops, wheat or barley, grown consecutively. With super-phosphate of lime alone, which, in a striking degree increased the yield of nitrogen in the turnips, reduced it in the succeeding barley, increased it greatly in the leguminous crops, and slightly in the wheat immediately following them, we have the average annual yield of nitrogen raised to 45·2 lbs. per acre, per annum, over the twenty-eight years; or to more than double that obtained by wheat or barley grown continuously by mineral manures alone. And it may be observed that where, in adjoining experiments, no leguminous crop was grown between the barley and the wheat, but the land was fallowed instead, the total yield of nitrogen in the rotation was very much less: the wheat succeeding the fallow yielding very little more nitogen than that succeeding the leguminous crops which had removed so much of it. In other words, the removal of the most highly nitrogenous crops of the rotation— beans or clover—has been succeeded by a growth of wheat, and assimilation of nitrogen by it, almost as great as when it has succeeded a year of fallow—that is to say, a period of accumulation from external sources, and no removal by crops.

One other illustration must be given of the power of plants of the leguminous and some other families to assimilate more nitrogen over a given area than those of the gramineous family. But before entering upon the bearing of the results in question on this particular point, it will be necessary to digress a little to call special attention to the conditions of the experiments under which the results were obtained; and it is the more desirable to do this, since the most important of Mr. Lawes' contributions to this Exhibition is an illustration of the results I am about to refer to.

Effects of manure.—I must here forestall a little what I shall have to refer to more fully further on, as to the effects of characteristically different substances on crops belonging to different botanical families. I will say briefly, then, that it is found that nitrogenous manures have generally a very striking effect in increasing the growth of gramineous crops grown separately on arable land, such as wheat, barley, or oats, all of which contain a comparatively small percentage of nitrogen, and, as has been illustrated, assimilate a comparatively small amount of it

over a given area when none is supplied to them in manure. The highly nitrogenous leguminous crops, on the other hand, such as peas, beans, clover, and others, are by no means characteristically benefitted by the use of direct nitrogenous manures, such as ammonia-salts or nitrates, though nitrates act much more favorably than ammonia-salts. Again, while, under equal conditions of soil and seasons, mineral without nitrogenous manures increase comparatively little the poor-in-nitrogen gramineous crops that are grown separately, such manures, and especially potass-manures, as has been seen, increase in a striking degree, the growth of crops of the leguminous family grown separately, and coincidently the amount of nitrogen they assimilate over a given area.

Such, then, is the result obtained in the separate growth, on arable land, of individual plants of the different families. Now, in the mixed herbage of permanent grass land, we may have fifty, or even many more species growing together, representing nearly as many genera, and perhaps eighteen or twenty natural orders or families. Of these, the Gramineæ generally contribute the largest portion of the herbage; and, on good grass land, if the Leguminosæ do not come second, they are at any rate prominent. The degree in which other orders are represented may be very various indeed, according to soil, locality, season, and other circumstances. In Mr. Lawes' park, at Rothamsted, nearly eighty species have been observed; but of many only isolated specimens, and it may be stated generally that about fifty species are so prominent as to be found in a carefully averaged sample of the hay grown without manure.

Experiments on the influence of different manures on this mixed herbage were commenced in 1856: at which time the herbage was apparently pretty uniform over the whole area selected. About twenty plots, from one-quarter to one-half an acre each, were marked out, of which two have been left continuously without manure, and each of the others has received its own special manure, and as a rule the same description year after year—and the experiments have now been conducted over a period of twenty years.

Under this varied treatment, changes in the flora, so to speak, became apparent even in the first years of the experiments; and three times since their commencement, at intervals of five years—namely, in 1862, 1867, and 1872—a carefully averaged sample of the produce of each plot has been taken and submitted to careful botanical separation, and the percentage, *by weight*, of each species in the mixed herbage determined. Partial separations have also been made in other years.

Mr. Lawes has contributed a large case of specimens to the exhibition, which shows the botanical composition of the herb-

age on selected plots in the seventeenth season of the experiments (1872). The quantities of the different plants there exhibited represent the relative proportion, by weight, in which each species was found in the mixed produce of the different plots; and the whole illustrates in a striking manner the domination of one plant over another, under the influence of different manures, applied year after year on the same plot.

The general results of the experiments may be briefly summarized as follows:—

The mean produce of hay per acre per annum has ranged, on the different plots, from about twenty-three cwt. without manure to about sixty-four cwt. on the plot the most heavily manured.

The number of species found has generally been about fifty on the unmanured plots, and has been reduced to an average of only twenty, and has sometimes been less, on the most heavily manured plots.

Species belonging to the order *Gramineæ* have, on the average, contributed about sixty-eight per cent of the weight of the mixed herbage grown without manure; about sixty-five per cent of that grown by purely mineral manures (that is, without nitrogen); and about ninety-four per cent of that grown by the same mineral manures, with a large quantity of ammonia-salts in addition.

Species of the order *Leguminosæ* have, on the average, contributed about nine per cent of the produce without manure, about twenty per cent of that by purely mineral manures (containing potass), and less than 0·01 per cent of that by the mixture of the same mineral manures and a large quantity of ammoniacal salts.

Species belonging to various other orders have, on the average, contributed about twenty-three per cent of the produce without manure; about fifteen per cent of that by purely mineral manures, and only about six per cent of that by the mixture of the mineral manures and a large amount of ammonia-salts.

Not only the amounts of produce, but the number and description of the species developed, have varied very greatly between the extremes here quoted, according to the particular character or combination of manure employed, and to the character of the seasons, as is strikingly illustrated by the arrangement of the specimens in the case, which, however, it should be borne in mind, show the composition of the herbage on the selected plots in one particular season only—namely, in 1872.

Obviously, these few remarks can only very inadequately indicate the interest of these curious illustrations of the domination of one plant over another in the mixed herbage of per-

manent grass land. Nor do we pretend to be able to give a satisfactory explanation of the variations induced, founded on the obvious or recorded difference in above-ground or underground character or habit of growth of the individual species. The whole of the results—agricultural, chemical, and botanical—obtained during the twenty years of the experiments are, however, now in course of arrangement for publication; and that we may not overlook such explanations as might be suggested from the point of view of the botanist and vegetable physiologist, as well as that of the chemist, we have associated with ourselves Dr. Masters in working up the botanical part of the inquiry; and I think Dr. Masters will agree with me in saying that much more has yet to be known of the difference in the physiological capability, so to speak, of the leaves of plants of different species, genera, and orders, and of the difference in the distribution, and in the feeding power, of the roots, before satisfactory explanations of the facts observed can be given. Surely, a wide field of investigation for the botanist and vegetable physiologist is here opened up to view!

(To be continued.)

ART. III.—*Observations on a property of the Retina, first noticed by Tait;* by OGDEN N. ROOD, Professor of Physics in Columbia College.

IN the Edinburgh Proceedings, 1869–70, vii, p. 605–607, Tait described an interesting observation, which has perhaps some bearing on Thomas Young's theory of color. While suffering from indisposition, he noticed each time on awakening from a feverish sleep, that the flame of a lamp seen through a ground-glass shade, assumed a deep red color, the effect lasting about a second. He suggests that the nerve fibrils in the retina also partook of sleep, and on awakening the green and violet nerves resumed their function somewhat later than the red. I have in my own case noticed some instances, which seem to point out that after a *nervous shock*, sudden or prolonged, the green nerves (adopting the theory of Young,) recover their activity later than the red, and probably later than the violet nerves. The first observation was made twenty years ago while recovering from the effects of chloroform, which had been administered by a dentist, well known at that time in Munich. Upon regaining consciousness, and raising my eyes to the face of the operator, I was a little surprised at not having previously remarked his unusually ruddy complexion, but the next instant

saw that this was due to an optical illusion, for his hair appeared of a bright purplish-red hue. The singular appearance lasted perhaps a couple of seconds, when his hair resumed its natural color, which was *white*. This observation corresponds with that made by Tait.

I give now an instance, where chronic effects of a similar character were noticed by me for a couple of weeks continuously, during convalescence from typhoid fever. In this case white objects appeared of a not very intense orange-yellow hue, the general effect on a landscape being such as is produced by the orange-yellow rays of the setting sun. Here the activity of the green and violet nerves was diminished relatively to that of the red. The auditory nerve was also evidently affected during the same period, but precisely in what way I did not ascertain.

It is a matter of yearly observation with me, that effects, similar in kind with those first noticed, are produced by prolonged exposure to bright white light out of doors. Under such circumstances white objects no longer appear pure white, but are tinted plainly purplish-red, and rather dull greens assume a gray hue, as though all the green in them had been neutralized, while strong greens are considerably reduced in intensity (saturation.) Upon leaving the blinding glare and entering a darkened room, it often for several seconds appears filled with a greenish haze.

Two of these cases and, probably that of Tait, point out, that our apparatus for the reception of waves of light of medium length, is more liable to be over-strained by nervous shocks or by prolonged excitation, than is the case with those designed for the reception of waves of greater or lesser length. Nervous derangement and prolonged excitation, are then causes, which may produce temporary green color-blindness.

Art. IV.—*On grains of Metallic Iron in Dolerytes from New Hampshire;* by George W. Hawes.

The presence of metallic iron in certain basalts and dolerytes has been repeatedly proved. It was first shown by Dr. Andrews that it was contained in the basalts of the Giant's Causeway.* Reuss has proved its presence in Bohemian basalts; and in this country it has been found in the Mesozoic dolerytes of New Jersey by Cook.†

In all these cases the iron has been detected by a microchemical method. If a portion of a rock is pulverized, and the

* Pogg. Ann., 1853, Bd. 88, p. 321.

† Cook, Annual Report of State Geol. Survey for 1874, p. 56.

magnetic constituents withdrawn by passing a magnet over the powder, any metallic iron which may be present in the rock can be recognized by treating this magnetic portion with an acid solution of sulphate of copper and then examining it with the microscope to see if any metallic copper is precipitated. If metallic iron is present it exchanges places with the copper, and crystalline aggregates of metallic copper, easily recognizable by their color and luster, will be seen. But as Dr. Andrews remarked in speaking of the Ovifak iron, in his inaugural address before the British Association last summer, it has never been found possible to detect with the microscope this iron which was known to be present. It is proposed here to point out the mode of occurrence of visible grains of metallic iron in dolerytes from New Hampshire.

Upon the Dry river, a small stream which gathers its waters from Mount Washington, there are numerous large dikes of chrysolitic doleryte, which cut through the old crystalline rocks. These dolerytes are composed of labradorite, pyroxene, chrysolite and magnetite, with a little mica; and, though they contain such decomposable materials, the rocks are remarkably fresh, and all the minerals are clear when looked at in thin sections with the microscope, showing no signs of alteration. This may be due in part to the remarkable compactness of the rock, and perhaps more to the great freshets in the spring time, which remove any soft or loose material.

Considering that the circumstances would be favorable for the preservation of metallic iron in these rocks if any were originally present, I tested for it according to the method before described, and the strength of the reaction was surprising. The magnetic constituents treated with sulphate of copper exhibited numerous bright crystalline aggregations of copper which were plainly visible to the naked eye. The reaction was so much more marked than any that I had obtained in testing the trap rocks of the Connecticut valley, which contain iron when not altered by decomposition, that I examined the sections to ascertain if it could not be seen under the microscope; and I found on shutting off the light from the mirror below and examining them with light reflected only from the section, that a few of the grains of magnetite possessed a bright metallic center, which had the luster of metallic iron, and which was very marked in the bluish-black magnetite. Taking an unmounted section which possessed one of these grains near its center, I treated it with sulphate of copper, when the grain was covered with a coat of copper, proving it to be iron. The following figure is drawn from a section of the rock, and represents it as magnified thirty five diameters. The black mineral is magnetite, and the light colored spot in

the large grain is the metallic iron. The other minerals of the slice are as follows: The white mineral with no cleavage but with irregular fractures is chrysolite (C); the mineral showing an interrupted cleavage is pyroxene (P); the shaded mineral with a perfect cleavage is black mica (M); and the white mineral which is clear and shows only a few impurities is labradorite (L). The chrysolite and biotite show an attempt at regular crystallization, while the other ingredients do not possess any regular external form, but the labradorite is finely striated by twinning, and this produces a beautiful effect when it is examined with polarized light. The magnetite is extremely magnetic, and, on being separated from the other material by a magnet, the grains retain magnetism and become little lodestones, and several quite large grains can be drawn along together with the end of a platinum wire. These rocks form a part of the series that will be described in the third part of the report of the New Hampshire Geological survey.

It has been supposed that the metallic iron of basalts results from the agency of carbon or some reducing agent, which acting on the magnetic iron at a high temperature has reduced a portion of it to the metallic state. The presence of this iron in the centers of the irregular grains of magnetite seems to indicate that the magnetite in this rock may have resulted from the oxidation of the iron.

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ART. V.—*On certain Phenomena of Binocular Vision;** by FRANCIS E. NIPHER.

IT is possible that the phenomena here described may have been observed before, but I have been unable to find any record of them.

1. Fold a sheet of writing paper into a tube about an inch in diameter. Look through the tube at some distant object

* Read before the St. Louis Academy of Science, Nov. 6th, 1876.

with one eye, and toward the open hand with the other eye, the edge of the hand being in contact with the tube. The dissimilar objects producing unlike images upon the retinæ, the sensations blend and a hole will appear to be cut through the palm of the hand, through which the tube passes. That part of the tube between the eye and hand will appear to be transparent, as though the hand were seen through it.

This experiment is very old, but seems not to have found its way into scientific literature.

2. Replace the hand by a sheet of unruled paper, upon which a drop of ink has been placed. By proper management, the ink blot may be made to appear within the tube, by so placing the paper that the hole which is apparently cut through it, coincides with the blot. Ordinarily the blot will then appear opaque, the paper immediately around it, and apparently within the tube, being invisible. The blot appears as it were suspended in space. By concentrating the attention strongly on objects seen through the tube, especially if they are strongly illuminated, the blot becomes more hazy, transparent, and may even be made to disappear altogether. The mental effort necessary to do this cannot be maintained more than a few seconds, and the spot will reappear. If the effort to cause the spot to thus disappear be kept up, the attention being strained to its highest pitch, the blot will disappear and reappear at regular intervals of a few seconds, the absolute time depending upon the illumination. It seems as though the organs exerted become fatigued, and relaxing for a few moments, refreshment sets in, which again renders possible the exertion necessary in causing the blot to disappear. It is possible that these experiments may be so made as to throw some light upon the conditions necessary in fixing the attention. Interesting experiments may also be made by substituting a fragment of a plane mirror for the sheet of paper. Looking through a rather large tube at a distant object with the right eye, and the reflected image of the left eye will appear staring up the tube, the adjoining parts of the head being invisible.

3. Substituting for the ink-blot a small hole cut through the paper, the small hole can also be made to appear within the tube, distinguishing itself by its different illumination, the surrounding paper being invisible, unless attention be directed too strongly to the paper in which the hole is cut. The relative illumination of the small hole, and the space immediately around it depends upon the relative illumination of objects upon which the tube is directed, and that of the sheet of paper exposed to the other eye.

4. Keeping the same arrangement, place at a distance of one foot from the end of the tube a sheet of paper so that objects

beyond it are still visible—arrange matters so that it is visible to the eye looking through the tube, but not to the other, directed at the small hole in the paper sheet. This second sheet will now appear to be traversed by a hole the same in size as that cut through sheet No. 1.

Cutting a small hole in sheet No. 2, matters are easily arranged so that it appears within the hole which was before seen within the tube. These experiments may be utilized in showing the simultaneous accommodation of the two eyes.

5. Tubes of this kind, blackened on the inside are very convenient in studying color sensations. Using two such tubes, look through one with the right eye, say, at red, through the other with the left eye at green paper, illuminated by the direct solar ray. The color sensations fade with marvelous quickness. Transferring both eyes to either color, say red, the eye fatigued by green sees the red greatly intensified, the effect being rendered the more striking by the simultaneous impressions received by the two eyes. Experiments in the combination of color sensations will readily suggest themselves.

The editor of the *Scientific American* has written something quite similar to some parts of this communication (Oct. 14), but a comparison of it with my short note in *Nature*, Aug. 10th, will show that I am not the borrower.

ART. VI.—*Notes on the Vespertine Strata of Virginia and West Virginia;* by WILLIAM M. FONTAINE.

Structure and geographical distribution.

THE eastern border of the unbroken area occupied by the Vespertine in the two Virginias may be taken as limited by the Main Alleghany, in the northern and middle portions of the area in question, and in the southern portion, by Peter's and East River Mountains.

As Prof. Wm. B. Rogers has shown, the rocks of the Vespertine, or No. X, compose the middle portion of the Main Alleghany from the Potomac to Pocahontas county. This range of mountains, for some distance south of the Potomac, is called "the Eastern Front Ridge of the Alleghany," while from the northern part of Pendleton county to the southeastern corner of Greenbrier county, it bears the name "Alleghany."

North of Pocahontas, according to Prof. Rogers, the range shows principally monoclinal westerly dips. The flexures here are comparatively broad and gentle. Hence the Vespertine and associated strata first dip gently westward, and then pass into a series of undulations, which extend nearly to the Ohio

River, declining more and more in abruptness. Owing to the increasing depth to which they are buried, the Vespertine strata are rarely brought to the surface in that direction by the flexures.

As we go south of Pocahontas the westward thrust which has affected this region, causes an increased elevation and flexing of the rocks. The structure of the Alleghany passes from monoclinal to anticlinal, with increasing steepness of dip, so that, in the vicinity of the White Sulphur Springs, where penetrated by the tunnel for the Chesapeake & Ohio Railroad, the strata stand nearly vertical.

Lower and lower rocks enter into its composition, in passing southward. As Rogers has shown, in the north, where monoclinal dips prevail, the lowest rocks seen in the east face of the mountain are those of No. IX or Catskill?. But near the White Sulphur, the core of the mountain is composed of the lowest Chemung, and, probably, Hamilton strata.

The development of an anticlinal structure, with increasing steepness of dip in passing southward, has had the effect of causing a belt of Vespertine rocks to be brought down on the east side of the mountain, and caught in a synclinal fold. This gives us the small coal beds seen near the Lewis Tunnel. At the same time the increase in the elevation and flexing of the strata southward from the northern part of Pocahontas county has brought up rocks lower than the Catskill?, not only in the Alleghany but over a belt about ten miles wide to the west, so that the east limit of the unbroken Vespertine, is thrown off to the western side of this area.

This belt shows strata all the way in the series, from the Oriskany to the Vespertine. The former barely appears in the lowest eroded places, and the latter shows merely small uneroded remnants of its lower portion. In the vicinity of the White Sulphur Springs, the strata throughout this area seem to be disposed in closed and contorted anticlinals overturned to the westward, which are separated by comparatively broad belts, in which the beds show moderately steep dips.

This disturbed belt is separated by a line of fault from the Vespertine strata. Here the transition is very abrupt, to a region which shows remarkably little disturbance. Prof. Rogers' description of the geology of the eastern corner of Monroe county would seem to show that the elevation of strata lower than the Vespertine in the Alleghany, and the belt to the west of it, is not maintained beyond the northeastern border of this county; for there we find that the eastern outcrop of the Vespertine area has closed in upon the Alleghany, while within the county this mountain chain is continued in Little Mountain, which is composed of upturned Vespertine strata.

With this disappearance of the elevated belt of disturbed Devonian strata, the fault which bounded it on the west also vanishes, but is succeeded by a much more important one, which begins some distance to the east of the termination of the Alleghany, in the northeastern edge of Monroe county. The rapid increase in the magnitude of this fault to the southwest soon swallows down the Devonian beds of the Alleghany, with their overlying bands of Vespertine coal beds, and brings the eastern outcrop of the Vespertine close to Lower Silurian strata. This fault, which runs not far to the west of Peters's and East River Mountains, bounds the Vespertine outcrop in that direction.

Every observer who has examined the structure of the country to the east and west of this fault, in the region extending from Monroe county to the southwest, has been struck with the remarkable difference in the amount of disturbance exhibited by the strata on the opposite sides of it. Prof. Lesley has given an excellent account of the condition of the country to the southeast of the fault above mentioned. The entire area here has been fractured, displaced, and folded, showing a truly astonishing amount of disturbance. On the northwest, or western side, we find the beds sometimes with their edges upturned, but they pass into an almost horizontal position in a short distance to the west. This is well shown in Prof. Lesley's section of Stone Mountain, where the conglomerate series is thus affected. Prof. Rogers, in his section of the strata in the northeast corner of Monroe county, gives a good example of this condition of things. Here the partially overturned beds of the Vespertine and Umbral, lying in the immediate vicinity of the fault, rapidly come down to nearly a horizontal position. In my account of the section near Greenbrier River, a similar structure will be shown. But here the line of fault separating the disturbed from the undisturbed region, is a minor one, developed by the rise of the Devonian belt near the White Sulphur Springs.

While the direction of this fault is thrown more in a northerly direction, and hence farther to the west than that of the one above described, yet it occupies the same relative position, and performs the same office, viz: that of checking the propagation of the disturbance through the strata to the west of it. This fault does not seem to continue far north, certainly not beyond Pocahontas county.

The country everywhere to the west of these last lines of fault, from Greenbrier county nearly to the Tennessee line, with the exception of a few undulations and disturbances in the vicinity of the fault, shows a prevailing northwest dip, as far as the Ohio River, which, as we go in that direction, brings

us upon higher and higher strata. This region may then be regarded as an eroded plateau, sloping from the east toward the Ohio River. The mountains laid down as existing in this region are simply uneroded remnants of higher and softer strata, resting upon a basal plane, formed by lower and harder ones, such as the Lower Carboniferous Limestone, and the sandstones of the Conglomerate Series.

I have attempted to give some account of the topography of this part of the State of West Virginia, in the "Resources of West Virginia," recently published under the direction of the "State Board of Centennial managers."

North of Pocahontas county the flexures along the east border show no fault, but are propagated with diminishing force far to the west. In this quarter the most westerly fault is the great one, running along the west side of the great Lower Silurian limestone valley of Virginia. The Professors Rogers, in their discussion of the structure of the Appalachian Belt in the Virginias, have well shown the gradation of folds, in the northern part of the area in question, into faults in the southern part. In passing south the anticlinals become closed, then overturned to the west, and finally fractured. This feature is shown, as I have explained above, in the Devonian area near the White Sulphur.

An inspection of the map of the Virginias will show that the straight mountain chains which extend from the southern part of the two states in a northeasterly direction to the northeastern corner of Monroe county, are then thrown farther west, and made to take a north-northeasterly direction. The more southerly chains are produced by resistant strata, brought up along lines of fault, the more northerly, by folds.

The following seems to me to be the course of events, which resulted in the production of the present structure of the country:

The westward thrust, which, at the close of the Carboniferous Age, uplifted the Appalachian Belt, found the strata along its present western border, for some distance south of the Potomac, with their power of resistance comparatively unimpaired by any previously existing tension. Consequently, the undulations arising from the thrust were propagated far to the west. But to the south the case was different. The western edge was already weakened by the tension produced by the development of the deep trough, in which the lower Carboniferous strata were deposited, and this tension increased with the increased depth of this trough to the south. Hence, we find first the development of a minor fault along the eastern side of Greenbrier county, which relieved the strata to the west of it, in a great measure, from the westward thrust.

Passing south, into still more weakened strata, the sudden development of the great fault near the Sweet Springs, in Monroe county, to the east of the southerly prolongation of the Alleghany, in like manner relieves the country to the west from the upheaving force, causing the Alleghany, and the contorted belt on its west, to disappear, and the mountain chains to assume a more easterly course. From this point southward, in the region of greatest tension, the fractures are more profound and numerous. Any residual impulse, unrelieved by the faults, seems to have been exhausted in producing flexures in the immediate vicinity to the west of the fault, and in raising the eastern border of the great coal field as a whole, producing a gentle westerly dip toward the Ohio.

No doubt the great freedom of this area, thus tilted, from flexures of any magnitude, is due in part to the great development of massive sandstones in the lower Vespertine, and in the conglomerate series in this section, which would produce great rigidity.

A somewhat detailed explanation of the connection supposed to exist between the faulted and folded portions of the country, and the deep trough occupied by the lower strata of Carboniferous age, has been given in the above named "Resources of West Virginia," in the chapter by Mr. Maury on the "Coal Field of West Virginia."

The Vespertine strata occurring to the east of the limit mentioned at the beginning of this article, are found in detached belts and patches, mostly of small extent. As might be expected, from the above account of the structure of the country, in the northern and middle portions, they occupy usually the lower parts of synclinal folds, while in the southern portion, they are confined to the vicinity of faults. In each case they are more commonly found along the flank, or at the foot of a mountain, formed by the more resistant lower portion of the Vespertine, or underlying strata.

The following are the more important of these belts, and the only ones which I propose to notice, since they may be taken as true representatives of all the areas to be found in the region where they exist.

1. The belt mentioned above, as occurring on the east flank of the Alleghany Mountain, near the White Sulphur Springs. This belt contains the coal strata and plant impressions seen at Lewis Tunnel. It is especially instructive, since it shows the strata lying immediately above the Chemung, as well as the junction of these last with the lower portion of the Vespertine. All the strata here are well exposed in the deep cuttings for the Chesapeake & Ohio R. R.

This belt extends an unknown distance north of the railroad,

probably to the northern part of Bath county. To the south, it terminates near the northeastern border of Monroe county. It occupies the bottom of a synclinal fold, and possesses but small width.

2. A much more extended and important belt, which lies about thirty miles east of the last. This commences in the northern part of Virginia, in the western part of Berkeley county, and extends thence south through the State, with some minor interruptions. It lies on the west side of the great Lower Silurian limestone valley, and close to the great fault which bounds it in that direction. In the northern and middle portions, the coal-bearing member of the Vespertine lies under the inverted massive sandstones of the lower member, and hence is found on the west side of the mountains, formed of this massive portion. In this part of the State, these mountains bear the names of "Great," and "Little," "North Mountain."

In the southern part of the State, the Vespertine strata are not inverted, but dip toward the fault. Hence in "Brush Mountain," the southern continuation of "North Mountain," the coal-bearing member lies on the southeastern face of the mountain. The great number of faults in this section has caused a small remnant to be caught and preserved, even within the area of the Silurian strata, as in the remarkable coal field of Price's Mountain, near Christiansburg in Montgomery county. I have been informed that coal has been discovered still farther to the east, within the limestone area, in the north end of Lick Mountain, in Wythe county. If this is true, it is without doubt Vespertine coal.

From the fact that all the strata, and the coals as well, thicken as we go east, it cannot be doubted that the Vespertine coal field extended considerably farther in that direction than any remnant now remaining. Leaving out of consideration the extension of these strata northward, into Pennsylvania, where they have been shown to contain coal beds, the area of the coal formation of this age, in Virginia and West Virginia, was by no means small. Judging only by the exposures which now remain, the belt of country over which well defined coal beds were formed, was more than 300 miles long, and fifty miles wide.

I have examined the exposures on the Greenbrier River, and at Lewis Tunnel, in the vicinity of the White Sulphur Springs, as well as those in the western edge of Augusta and Rockingham counties in Virginia, and in Montgomery county. I will give in the remainder of this article, some of the facts observed at these points.

The strata from the top of the Chemung to the base of the "Productive coals," in the two Virginias, pass into each other

so gradually, that, in subdividing this great mass of sediment, one is forced to select the dividing planes somewhat arbitrarily, and to take for his guide, physical changes in the strata. The most natural horizon, to select as the upper boundary of the Vespertine in the Virginias, as it seems to me, is the base of the "Lewisburg," or "Lower Carboniferous Limestone." Yet, as we proceed north into Pennsylvania, this rock is absent. This is also the case in the eastern exposures in Virginia. Along the Greenbrier River there are certain red beds, underlying the limestone in question, and resting on the coal-bearing member of the Vespertine. Professor Wm. B. Rogers, if I understand his measurements correctly, places these in his Umbral, or No. XI, as he does the Lower Carboniferous Limestone, here exposed. There are two objections to this, I think. The physical character and composition of these red beds assign them more naturally to the Vespertine than to the limestone.

Another, and more important objection is, that if the lowest of these beds be made the base of the Umbral, then the great limestone formation must be considered as a subordinate member of the comparatively restricted Umbral series. For these reasons, I include the beds in question, in the Vespertine series. The Umbral series naturally begins at the top of the "Lewisburg," or "Lower Carboniferous Limestone," at least in the Virginias.

The Vespertine Strata on Greenbrier River.

Commencing at the fault above described, which occurs a little west of Caldwell Station, on the Chesapeake & Ohio R. R., and about six miles west of the White Sulphur, we find on the east side of the deep channel cut by a small stream, highly contorted, and overturned, strata of the Catskill?, while on the western side, and only 100 yards distant, the upper red beds of the Vespertine are seen dipping at an angle of only three or four degrees eastward, toward the contorted strata. These compose the base of the high hill there seen. The middle and upper portions of this hill are composed of the Lower Carboniferous limestone, into which the red strata pass gradually, by several alternations of red marlite and limestone. Passing west, along the railroad, the cuttings show that the red rocks rise gradually with a steepening easterly dip, until within 100 yards of the first exposure of the coal-bearing or middle member of the Vespertine, when they rise suddenly, at an angle of 45°.

These strata are composed almost entirely of deep red crumbling marlites. Some insignificant beds of flaggy, reddish, and gray sandstones, occur in the passage beds near the base of the limestone, and toward the middle of the series. Some of

the thin flags at the top of the system show beautiful ripple marks. Toward the base, as we approach the coal-bearing member, the marlites are no longer of uniform red color, but are variegated with green and grayish splotches. The principal portion of the red strata much resembles some of the red shales of the supposed Catskill, which will be described farther on. The entire thickness is by estimate 250 feet.

This red upper member seems, from the measurements of Professor Rogers, to thin out to the north. As remarked above he puts it with the Lewisburg limestone, which is probably the equivalent of the St. Louis and Chester groups, in his Umbral series.

In his measurement of the Umbral in Greenbrier Mountain, near Huntersville in Pocahontas county, he puts fifty feet of red shales under the limestone. This point is thirty miles north of my section.

Still farther north, on the Potomac, near Westernport, Professor Rogers gives no red beds under the limestone, but shows that fifteen feet of red shales and sandstone occur about twenty feet from the base, which is composed of reddish and sandy gray limestone.

In the vicinity of the Greenbrier River, as above mentioned, the coal-bearing portion of the Vespertine rises boldly from beneath the red marlites, and forms cliffs of imposing height near the railroad bridge. These strata, however, do not attain a sufficient height to disclose the white sandstones and conglomerates, which form the lower member of the Vespertine in the two Virginias. Across the river they soon come down with a westerly dip, and disappear under the limestone to appear no more. This broad anticlinal seems to be the last important undulation affecting the strata in a westerly direction, for these maintain apparently a westerly dip nearly to the Ohio River.

In my article on the "Conglomerate series of West Virginia," published in the numbers of this Journal, for April and May, 1876, I have given some account of the geology of the country lying in that direction.

The middle member of the Vespertine as disclosed here, shows at its top, about seventy feet of rather siliceous, bluish gray sandstones, in thin beds, and of very firm texture. Under these occur about forty feet of thinly bedded, gray flags, which show throughout a curious distribution of carbonaceous matter. Fully fifty, pretty persistent, thin strings of carbonaceous material, are distributed over this space, being usually not more than an inch or so thick, but sometimes suddenly swelling out to the thickness of nearly a foot. No underclays exist, and all the material was plainly derived from drifted vegeta-

tion. This is also indicated by the frequent mixture of the carbon with the substance of the sandstones.

But while this portion of the field seems to have been under water, a portion of the neighboring area was in a condition to permit the development of a considerable coal bed. I have reliable information that some two and a half miles north of this point, and near the river, a coal bed exists at this horizon. At one time attempts were made to work it, but the coal proved to be too impure, and full of sulphur. It is locally about four feet thick. This is the coal bed mentioned by Professor Rogers, as existing on the river near Lewisburg.

Beneath the above mentioned carbonaceous portion, come 120 feet of firm gray, and brownish sandstones, and then forty feet of very flaggy, gray, soft sandstones and shales, with some layers of fissile black shale, containing indistinct vegetable impressions, mostly leaves of Lepidodendra. The lowest rock seen shows about twenty feet of dark gray, compact, fine grained sandstone, full of specks of pyrites, and containing in nests and pockets of yellow ochre poorly preserved impressions of shells. The entire thickness, here shown, of the middle member, is by estimate about 290 feet.

Professor Rogers shows that farther north, where the Vespertine forms a portion of the mass of the Alleghany Mountains, this member shows pretty much the same features, but that the amount of coal is much smaller, since it appears only in occasional thin strings of very small lateral extent.

Vespertine Strata near Lewis Tunnel.

Twelve miles east of the last mentioned locality we find the Vespertine rocks disposed in a narrow belt along the east side of the Alleghany Mountains. The Chesapeake & Ohio Railroad issues from this mountain, on the east side, in a deep cut made in Chemung strata, which dip about 75° southeast. Passing along the railroad eastward, we enter first the strata intermediate between the Chemung and Vespertine, which are probably Catskill, and after passing through these, see the lowest beds of the Vespertine, coming next in order. The dip flattens down rapidly in going east, until in the Vespertine strata it is not more than 25°.

The Chemung here is much like that of New York. Alternations of flaggy sandstones and shales, weathering olive brown in color, form the principal portion of the mass. Toward the top, rather massive, dull gray, and dingy brown sandstones occur, with some portions containing pebbles as large as a garden pea. Thin layers, crowded with impressions of shells, occur at intervals, being found even in the coarse sandstones. The highest strata showing Chemung fossils, are these coarse sand-

stones; succeeding them, the rocks show a decided change, and in this portion, the Catskill beds, if they exist at all here, must be found. The following is a section of them, with the thickness estimated in part. (1.) 120 feet of alternations of deep red marlites, and thick-bedded, rather argillaceous, reddish-brown sandstones. The sandstones and marlites are in about equal proportions. (2.) Seventy feet of dark red marlites, interstratified with ochreous sandstones of very argillaceous character, and showing balls and nests of brown hematite, arising from balls of pyrites. The sandstones when fresh are of dull brown color, but in weathering, assume yellowish-brown hues, in spots and patches. (3.) For 150 feet the ground is not well exposed, yet appears to be occupied by strata like the last, with a greater predominance of the sandstone. In (2), the marlites are confined to the lower portion next to (1). These three members, possessing a thickness of 340 feet, in which ferruginous matter abounds, are in all probability of Catskill age, but as they, so far as I know, contain no fossils, the question cannot be answered with certainty. These are succeeded by about 500 feet of flaggy sandstones, with interstratifications of shales, all when fresh dingy yellow, or brownish gray, but weathering to a dull brown color. These strata are of still more problematical age. As however in the eastern exposures, the Vespertine lower member seems to thicken at their expense, I include them with it. The junction of these beds with the lowest undoubted Vespertine strata, is here concealed by slides, as is partially, a considerable portion of their upper member.

Above the highest of these beds we have a decided change in the character of the deposits, and here I place the base of the Vespertine. This rock is a white, pebbly, highly siliceous sandstone, in the lowest portion seen. Its base is not exposed here. The pebbles are mostly small, but some of them attain the dimensions of half an inch. The great mass of the rock, especially the middle and upper portions, is a coarse sandstone of impure white color, becoming somewhat argillaceous at the top. The thickness seen was about sixty feet. This rock, it will be remembered, was not brought up at the place examined on Greenbrier River.

This is one of the most persistent and highly characteristic members of the Vespertine. Though always containing conglomerate bands, and marked by its siliceous character, it shows considerable changes in thickness, and the coarseness of its texture. Along the Greenbrier River the conglomerate portion, when exposed, often shows pebbles an inch in diameter. Professor Rogers mentions an exposure near Huntersville where the pebbles are even two inches in diameter.

Next above the sandstone member at Lewis Tunnel, we find

the middle member as on the Greenbrier River, containing gray flags with coal. It is here fully exposed, and is by estimate about 350 feet thick.

The base is composed of forty feet of argillaceous, thick-bedded sandstones of a dull yellowish gray color, succeeded by twenty feet of firm olive colored sandstones. Some one or two thin films of coal occur in the first named, associated with black shale. The second stratum brings us to about the horizon of the lowest rocks seen on Greenbrier River. The succeeding strata here are in the main much like those west of the White Sulphur, being mainly gray flags. About fifty feet above the last mentioned stratum we find a true coal system, showing underclays with rootlets. The following is a section of it, beginning at the base:

1. Bluish-black, sandy shales, 5 feet.
2. Fire clay, 5 inches.
3. Coal, 8 inches.
4. Brown, flaggy sandstones, 3 feet.
5. Slaty coal, 6 inches.
6. Black shale, 12 inches.
7. Gray sandstone, 30 feet.
8. Fire clay, 12 inches.
9. Coal, 1–2 inches.
10. Fire clay, 5 feet.
11. Slaty coal, 5–6 inches.
12. Sandstone, 3 feet.
13. Black sandy slate, 15 ft.

No. 7 contains films and streaks of coal from floated vegetable matter. No. 10 is full of Pinnularia rootlets. No. 13 shows plainly the marks of considerable erosion of the underlying beds. It is charged with carbonaceous matter, and contains films and fragments of coal. Indeed there are evident signs that several of the small coal beds suffered considerably from erosion, before the deposition of the overlying strata. The lower part of No. 13, for some four or five feet, contains large angular fragments of No. 1, mixed with others from the underlying Devonian brown sandstones. Some of the fragments are three or four inches in diameter. With the exception of No. 1, all the black shales of the section seem to be composed of material derived from the red and brown Devonian strata. On losing by weathering the carbon to which they owe their black color, they assume reddish and brown hues.

The coals are really two in number, disposed in an upper and lower double bed, about thirty feet apart, which accords well with their distribution throughout the Vespertine coal field. The material is very impure, slaty and full of sulphur.

Over No. 13 we find about seventy-five feet of firm siliceous, rather coarse, bluish-gray sandstones, containing fragments of the lower coal-bearing rocks, with drifted stems and pieces of coal. Lewis Tunnel is cut in these rocks.

Over this we have twenty feet of gray sandstone of firm texture, graduating into ten feet of firm thin bedded shales,

black when fresh, but weathering brown. This last contains the small coal bed at the entrance to Lewis Tunnel, and has afforded all the plant impressions found there. The coal is quite local, and has been found nowhere else so far as I know. This horizon however, in other places, often yields abundant plant impressions.

At the top we have some alternations of dark shales, with olive, and reddish marlites for thirty feet, and finally red marlites. No limestone was seen above the red marlites. The conditions here indicate a quieter deposition of sediment than that which took place near Greenbrier River, for there the firm gray flags are succeeded abruptly by the marlites. The uppermost coal bed here exposed is, at its thickest, about twelve inches, but soon passes into shale.

We find from the above data that in this section the Vespertine strata may be divided into three members.

1. A lower member, characterized by siliceous sandstones and conglomerates. Thickness exposed, sixty feet. With this should probably be counted 500 feet of underlying, more argillaceous flags, giving a total of 560 feet.

2. A middle member, characterized by the predominance of gray sandstones containing coal. Thickness, about 350 feet.

3. An upper member, consisting almost entirely of red marlites, and having a thickness of about 250 feet. This would give the entire group a thickness of 1,160 feet.

It will be seen that, as the base of the lower member is nowhere exposed in this region, sixty feet cannot be taken as its entire thickness. I am of the opinion that it is considerably greater. Professor Rogers, in his descriptions of the Vespertine, nowhere gives any descriptive section of the strata, so that we are left in doubt as to what stratum he assumes as its base. It is plain that he does not include the red overlying strata in it; this makes it difficult to use his measurements, as a basis for comparison. He gives the thickness on the Potomac near Westernport, as only 200 feet, while near Lewisburg he says it has increased to 800 feet. This seems in any event, to establish the fact of a considerable thickening to the south.

[To be continued.]

ART. VII.—*On the production of Transparent Metallic Films by the Electrical Discharge in exhausted tubes; by* ARTHUR W. WRIGHT, Professor of Molecular Physics and Chemistry, Yale College.

THE spectra of gases contained in vacuum-tubes, which have been prepared by the use of the mercury pump, usually exhibit lines caused by the presence of the vapor of this metal. In some cases this is no disadvantage, since they serve as convenient reference points in fixing the position of the other lines or bands observed. As the mercury vapor is naturally an excellent conductor of electricity, however, there is often reason to suspect that its presence may affect the character of the discharge somewhat, and its removal becomes desirable. In some recent experiments by the writer this end was obtained by placing in each tube a few pieces of clean gold foil loosely rolled into small pellets. As this metal is readily amalgamated it will, after a time, take up the mercury vapor, causing the disappearance of its characteristic lines from the spectrum. A still better method is to wrap a small piece of the foil about the end of the electrode, or to attach to it a short gold wire. The gold will be volatilized and deposited upon the walls of the tube in a very thin layer, thus exposing a much larger surface to the action of the mercury vapor, in the manner described below.

In some of these experiments the tube under examination was so placed that the gold lay at the bottom of the upper portion, at the point where the capillary part is attached. In this position it was exposed to the action of the more intense discharge through the narrow part, and after a time it was found that a lustrous and coherent film was deposited upon the glass, the gold having evidently been volatilized by the electricity and condensed upon the walls of the tube. In order to study more conveniently the conditions under which the best effects might be produced, a loose roll of the foil was placed in the middle of a tube about five millimeters in caliber, having a branch near one end for the purpose of withdrawing the air, and with platinum electrodes inserted into the ends. This was exhausted until a discharge from an induction coil passed readily, when it was found that the gold was speedily deposited upon the tube as before, and by shaking the foil along, a considerable area was covered with it in a short time. It appeared, even under the microscope, as a perfectly continuous film, forming a brilliant mirror, and showing the characteristic green

color by transmitted light very beautifully. When the tube was afterwards rather strongly heated the gold lost its mirror-like surface in the thinner parts, assuming a frosted appearance, and the light passed through it had a fine ruby color, conforming in this to what was observed by Faraday in his experiments on the relation of metals to light.* A singularity in the result was the fact that the volatilization occurred only at that end of the foil which was made a negative pole. This was observed to be the case in all the subsequent experiments, except that in one or two instances where a powerful discharge had been maintained for a considerable time a very slight deposit was observed at the positive end also.

As the matter appeared to be of interest with respect to its furnishing a new method of producing transparent metallic films, the investigation was extended to a considerable number of metals. Various forms of tubes were employed in successive trials, but the method found most advantageous was the following: clean tubes of white glass, about fifteen centimeters in length, and with a caliber of from four to six millimeters, were provided in the middle with a small branch tube for attachment to the pump. In the ends were placed the electrodes formed of the metals to be examined. These were generally in the form of thin wires from one-fourth to one-half a millimeter in thickness. About one centimeter of this was enclosed in a thin glass tube about three centimeters long, drawn out of the same piece as the main tube, and made so fine at the end as just to receive the wire. A platinum wire was placed in the other end, so as to touch the first wire, and sealed in. This was then carefully sealed into the end of the main tube, the electrode being in its axis, and the platinum wire projecting. It was necessary to cover the latter thus in the interior to prevent its giving a deposit upon the tube with the metal under examination. The tube was now exhausted to a tension of one or two millimeters, or so far that, when the discharge from the induction coil was passed through it, the glow surrounding the negative pole filled the tube along the whole extent of the electrode. After the coil had been put in operation for a few minutes a deposit was formed upon the glass, appearing at first as a mere darkening or discoloration, which, gradually becoming deeper, finally began to show metallic luster, while still suffering the light to pass freely. In almost all cases it covered the whole area of the glass opposite the electrode, but did not extend much beyond it. After the film was sufficiently developed the small branch was closed with a gas flame, the tube drawn off, and sealed.

* Experimental Researches in Chemistry and Physics.

For metals readily oxidized it was necessary to fill the tubes with some gas which would not act upon the deposit formed, as otherwise it was impossible to obtain good results. In these cases the air was first thoroughly removed, the tube filled with pure dry hydrogen, and then exhausted. In a few cases the tubes were refilled with hydrogen several times to ensure the complete removal of the oxygen. The perfection of the film was found to depend also in some measure upon the steadiness of the electrical action, and the proper regulation of the power of the current used When the Holtz machine was employed as a source of electricity no effect was obtained without condensers, and with them the discharge, at least with the tension of gas used, did not occur in such a manner as to yield good results. The trifling deposit obtained in this way was opposite the positive electrode. Possibly by exhausting the tubes so as to reach a much lower tension the electro-machine might be made available, but the induction coil is both efficient and convenient.

With a gold wire one-third of a millimeter in diameter and four centimeters long, an exquisitely beautiful deposit was formed over a space a little longer than the wire. The first noticeable effect was a slight discoloration of the tube by the deposited metal, while it was still too thin to show the metallic luster by reflected light. The tint was pinkish, inclining to violet, resembling that at the more refrangible end of the spectrum. As the film increased, the tint passed through blue, bluish-green, and finally, when of sufficient thickness, it appeared a clear, brilliant green, slightly inclining to bluish-green. By reflected light the film has a splendid luster, and the full golden color. It thins out gradually at the extremities, and becomes imperceptible at a point five or six millimeters from the end of the wire, with the same gradation of tints as was observed in its formation. The metallic reflection fades out in a similar manner, but ceases before the coloration.

With silver wire of about the same dimensions, the coating upon the tube was scarcely less beautiful and perfect. The full luster was developed gradually, and the light transmitted by the completed film is a pure, deep blue. Copper gives a fine lustrous mirror, appearing dull green by transmitted light. It is volatilized with more difficulty than the preceding metals. Bismuth on the other hand is obtained in a thin film with extreme ease, a battery of three small Grove cells with a coil giving a half inch spark producing the desired result in two or three minutes. The film is very transparent, and has a color such as would be produced by mixing a clear blue with a pure gray or neutral tint. The metallic layer is remarkably uniform, and of great beauty, possessing a brilliant luster by reflected light.

Platinum is volatilized with comparative ease, especially in a narrow tube. Its deposition on the glass in this way is a familiar occurrence, as few of the common vacuum tubes which have been subjected to the action of the induction coil for a long time fail to show the effect. In a small tube the layer is very bright, and is easily made thick enough to be quite opaque. When sufficiently thin, it transmits light of a gray color, with a slight bluish tinge. Palladium also is deposited in a thin layer without difficulty, and appears of a smoky brown color by transmitted light. Lead forms a very even film, with the characteristic color of the metal, though it has but a comparatively feeble luster. It has a high degree of transparency, appearing of a smoky-brown color, inclining to an olive tint when very thin. Thorough exclusion of the oxygen and vapor of water is necessary to the successful formation and preservation of the film, as when exposed to the air or moisture it is destroyed by oxidation in a very few minutes.

Zinc and cadmium yielded brilliant mirrors, with a white, silvery luster, and appearing deep grayish-blue by transmitted light, with a barely noticeable inclination to purple. It is less deep in tint than the light passed through silver, but deeper than that from bismuth. There was no perceptible difference between the two metals, unless it were a slightly greater intensity of the coloration in the case of the zinc.

Aluminum was volatilized with considerable difficulty, requiring five or six cells and a powerful coil. It formed a mirror-like film, which by transmitted light had a brownish color, but the result was not entirely satisfactory. Magnesium yielded even less readily, and showed no effect at all when tried with the means which had given good results in the other cases. It was necessary to reduce the electrode to a very fine wire, and this was enclosed in a tube of only 3·5 millimeters caliber. The larger coil was used, and the power of the battery gradually increased to six Grove cells. Not the slightest effect was produced when a smaller number was employed, but after the application of this power for a few minutes, the electrode was suddenly surrounded by a burst of green light, and the deposit was formed almost instantly upon the glass. It had a brilliant luster, and when the light was seen through it, a grayish-blue color similar to that of zinc or cadmium, but less clear.

Tin did not give very satisfactory results, as when the electrode was made small enough for the purpose it was difficult to avoid fusing it. The film when obtained was not as fine as those produced with the other metals mentioned, but had in some parts a silvery metallic luster, and was sufficient to show that when seen by transmitted light the metal appears of a brownish gray or sepia tint.

Interesting results were obtained with iron, which gave a very beautiful and perfect film, having a brilliant luster, and a high degree of transparency. The light transmitted by it is very nearly of a pure neutral tint, though with a faint tinge of brownish. The electrode was a wire 0·3 millimeter in diameter. This was carefully cleaned, and the tube filled with dry hydrogen three times before the final exhaustion. Without this precaution it is impossible to obtain reliable results, as the metal is partially oxidized, and the film not only stained, but its color by transmitted light changed to brown, or even to deep orange-yellow. This was the color exhibited by the film obtained in the first trial, in which the tube was filled with air. Externally it exhibited a vivid iridescence, in various colors, but at the extremities of the deposit the metal had its proper luster. Subsequent trials in which the tube was once filled with hydrogen gave better results, but the yellow tint and the iridescence did not disappear until the thorough removal of the oxygen and moisture, as described.

For those metals which are not readily obtained in the form of thin wires, a modification of the process was employed, as follows: a tube open upon one side was made by softening the end of a glass tube in a gas flame and drawing out one edge with another piece of glass. A trough was thus formed, at first shallow but growing deeper and deeper as the whole edge began to be drawn upon, and by properly adjusting the heat applied, it could be made as fine as desired. A tube of this kind from half a millimeter to a millimeter in diameter with a platinum wire inserted in the closed end, and with the open end evenly and firmly packed with filings or powder of the substance to be examined formed the electrode, which was used in the ordinary way.

Nickel and cobalt were experimented upon by this method, and films obtained, but as the removal of the oxygen was not sufficiently complete they were less perfect than those produced from the other metals, though sufficient to show that the color by transmitted light is gray or brownish gray. Tellurium employed in the same way afforded a very brilliant layer, which gave to the light seen through it a dull purple color.

At the suggestion of Prof. Dana an experiment was made with magnetic oxide of iron, native magnetite in powder being employed with one of the small troughs. It was volatilized with difficulty, but apparently without decomposition, and formed a somewhat lustrous film, appearing gray-brown by transmitted light. The result is of interest with reference to the occurrence of thin, somewhat transparent layers of this substance in certain micas, where it has the same color as that observed in this experiment.

In Faraday's experiments deposits of several different metals upon plates of glass or other materials were obtained by passing the spark from a Leyden battery between the points of wires near the plates in an atmosphere of hydrogen. Films so obtained are more or less irregular, and he describes them as apparently not entirely continuous. Those formed by the method here described, however, are generally very uniform and coherent, and even under the microscope appear to be perfectly continuous. For a study of the optical properties of the metals they can be formed upon narrow slips of plane glass introduced into the tubes by the side of the electrode. Simple examination of the tubes with a Nicol's prism shows that these films, at least in the case of gold, silver, iron, zinc and cadmium, which have been tried by the writer, polarize the light transmitted by them powerfully, and the degree of polarization appears to increase with the incident angle as far as observation can be conveniently carried, which implies a very high refractive index. It might be expected that the light should be elliptically polarized, but this point was not determined, and the optical properties of the films remain for further study.

With respect to the relative energy of electrical action necessary to volatilize the different metals the observations were hardly precise enough to warrant the statement of a definite law. Bismuth was volatilized most readily of all, gold and silver with but slightly less facility. Platinum, palladium, lead, tin, zinc and cadmium yield less readily, while copper, iron, nickel and cobalt require a rather intense discharge and are volatilized with some difficulty. Aluminum requires an energetic electrical action exerted for a long time, and the electrode must be a quite fine wire. Magnesium is acted upon still less readily, and is by far the most difficult, of all the metals tried, to be obtained in the state of a thin layer. Success was attained by the use of an energetic battery of five or six Grove cells, with a coil capable of giving two-inch sparks, the electrode being a wire cut from a thin ribbon of the metal and not more than one-fifth of a millimeter in thickness. Even then no effect was produced till this was enclosed in a very narrow tube by which the electrical action was concentrated. The electrode itself appeared bright green, showing that the discharge did act upon the metal, forming a thin envelope of vapor about it, which did not reach the glass however until the power of the current was increased and the size of the tube considerably diminished. It will be seen that the heavy metals, that is, those with high atomic weights, are most readily volatilized, while those with smaller atomic weights oppose great resistance to the electrical action, and those with medium weights occupy an intermediate position; but the

fusibility, tenacity, and electrical conductivity also appear to exert some influence as to the place of the different metals in the list.

It may be observed also that where it is desirable to avoid discoloration of vacuum-tubes by the metallic deposit, this can be effected by making the electrode within the tube of aluminum or magnesium, the interior portion of the platinum wire which passes through the glass being itself covered with a small glass tube. Of the two metals magnesium is the best, as a wire half a millimeter in diameter would not be at all affected by discharges of the intensity ordinarily used with vacuum-tubes, nor would it be so easily fused or rendered red hot as a wire of platinum. Of course these metals could only be used with gases which would have no chemical action upon them.

Yale College, December 13, 1876.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the so-called Crystallized Boron.*—Hampe has prepared and submitted to careful examination both of the forms of the so-called crystallized boron, the black and the yellow, and finds that neither is pure boron, both being compounds of this substance. For the preparation of the black variety, 200 to 400 grams of fused coarsely pulverized boric acid was placed in an English clay crucible, a piece of aluminum weighing 100 to 200 grams was laid upon it and covered with boric acid, and then the cover of the crucible was luted on with clay. The whole was enclosed in a Hessian crucible, the space between the two being filled with quartz sand. The secret of the production of the black crystals consists in the absence of carbon in the crucible. The fusion was effected in a melting furnace, the fuel used being coke, and the time of heating three hours. By closing the draft almost completely, the cooling took place very slowly, requiring from 12 to 18 hours; the crystals being increased in size proportionally. On breaking the inner crucible when cold, the upper layer of the fused mass was glassy and consisted of aluminum borate. Within this was a thin dense very hard layer of pure alumina, which surrounded the regulus. The free surface of the metal as well as the cavities in it were covered with magnificent black crystals, which were obtained on solution of the aluminum, accompanied by red hexagonal plates of the aluminum boride of Wöhler and chocolate-brown crystals of silicon. The yield was small, only 2·5 to 3 grams being obtained from 100 grams aluminum, one gram of which proved completely pure. Various other methods of preparation were tried; but the yield was less in every case. The crystals are monoclinic prisms, have a brilliant metallic luster,

are black in thick but dark red in thin layers, become blued like steel when heated in the air though not combustible when heated in a stream of oxygen. Their hardness is between 9 and 10, their density 2·5345. Concentrated hot nitric acid dissolves them slowly, fused potash and lead chromate rapidly. On analysis they yielded 17·30 per cent of aluminum and 82·70 per cent of boron, corresponding to the formula AlB_{12}. The yellow quadratic crystals were obtained by effecting the fusion in carbon crucibles; one melting, which was on a large scale, yielding 5·528 grams pure crystals, on some of which the octahedral edges were 4 mm. long. They are honey-yellow in color, very brittle, harder than corundum and nearly as hard as the diamond, and have a density of 2·615. On analysis they gave as a mean: Aluminum 13·15, iron 0·24, copper 0·04, carbon 3·76, boron (by difference) 82·81; corresponding to the formula $C_2Al_3B_{48}$. All attempts to prepare pure boron crystallized were fruitless. The author is now examining the so-called amorphous boron in this direction.—*Liebig's Annalen*, clxxxiii, 75, Oct., 1876. G. F. B.

2. *On the Constitution of the Phosphates.*—Berthelot and Louguinine have made a thermic research on phosphoric acid with a view to determine its basicity. They studied the heat-changes characterizing the union of this acid with two widely different bases, ammonia and baryta, and those produced by water and by various acids of different energy upon the three classes of phosphates. To these, they added alkalimetrical evidence. The conclusion which they reach is that the three equivalents of base, successively united to phosphoric acid, are thus united with very different values; the first equivalent being comparable to that of the nitrates or alkali chlorides, the second to that of the carbonates and borates, and the third to that of the alkali alcoholates. When for example, phosphoric acid and soda unite, the union of the first equivalent of the base evolves 14·7 calories, the second 11·6 calories and the third 7·3 calories; while in the case of a true tribasic acid like citric, the quantity of heat is constant for each equivalent, being in this case 12·7 calories. In the case of ammonia, no heat at all is evolved on adding the third equivalent, and hence no triammonium phosphate exists. In view of the results obtained, the authors say that phosphoric acid cannot be a tribasic acid, at least in the same sense as citric acid, the third equivalent of base being separated even by dilution; nor can it be a dibasic acid like sulphuric, oxalic, or tartaric acid, since the second equivalent of base is not neutralized by the acid and is entirely separable by hydrochloric and nitric acids and even partially by acetic. Hence they regard it as an example in inorganic chemistry of what in organic chemistry are called monobasic acids with a mixed function.—*Ann. Chim. Phys.*, V, ix, 33, Sept., 1876. G. F. B.

3. *On the Critical Point of Liquid Carbon Dioxide.*—Hartley has made further examinations of the liquid enclosures in minerals and has determined with care the critical point of temperature

for a large number of those composed of liquid carbon dioxide. Curiously enough this point was found to vary considerably: In topaz, in three specimens, the critical point was 28·5°, 26·5° to 28°, and 27·5° to 27·6° C.; in two specimens of tourmaline, from America, it was 27·27° and 26·9°; in five quartz specimens, it was 30·95°, 30·95°, 32·5°, 33·7° and 29°; in a beryl from Lurat, it was 30·92°; in three oriental sapphires, 30·5° to 31°, 25·5° to 26°, and 29·5°. The author explains this lowering of the critical point by the fact observed by Andrews that this effect is produced by the presence of an incondensable gas, perhaps nitrogen. The raising of the critical point appears to him to be due to hydrochloric acid gas. The facts observed seem to the author to have a bearing on the question of the formation of some of these minerals, and he suggests that corundum may have been formed by the action of aluminum chloride or fluoride upon calcium carbonate, producing alumina and carbon dioxide; the latter being condensed, would form cavities in the alumina crystals and would liquefy on cooling. If the reaction were dry, the cavity would contain only the dioxide; but if moisture were present, it would contain water also. With reference to the diamond, he suggests that it may have been formed by the action of reducing agents upon very highly compressed carbon dioxide at temperatures above its critical point. —*J. Chem. Soc*, XXX, 237, Sept., 1876. G. F. B.

4. *On the Spectra of Indium.*—CLAYDEN and HEYCOCK while observing the spark spectra of the metals, in the Cavendish Laboratory, Cambridge, noticed that instead of the three lines which are ordinarily supposed to constitute the spectrum of indium, the spark spectrum really contained sixteen. The wave-lengths of the three lines are given by Thalén as 4532, 4509 and 4101 tenth-meters. The second and third only of these lines are visible in the spark-spectrum. The wave-lengths of the sixteen lines the authors give as follows: 6906, 6193, 6114, 6095, 5922, 5905, 5862, 5820, 5722, 5644, 5250, 4680, 4656, 4638, 4510, and 4101 tenth-meters. The first of these lines is remarkable for its low refrangibility, only potassium, strontium and antimony giving lower ones. The wave-lengths were not measured directly apparently, but obtained by interpolation from the scale of the four-prism spectroscope with which the measurements were made.—*Phil. Mag.*, V, ii, 387, Nov., 1876. G. F. B.

5. *On the Preparation of Hydroquinone.*—WESELSKY and SCHULER have discovered a new and comparatively simple method of preparing the diatomic phenol of the ortho or 1 : 2 series, hydroquinone. If nitrous acid vapors be conducted into a cooled etherial solution of phenol, the mass is filled in a short time with crystals of diazophenol nitrate. This salt dissolved in dilute sulphuric acid (one of acid and two of water) mixed with alcohol and ether added, becomes sulphate which by precipitating with barium chloride can be easily be converted into chloride. These salts are identical with those prepared by Schmitt from the non-volatile mononitrophenol of fusing point 110°. If now an

aqueous solution of one of the above salts, preferably the sulphate, containing 10 to 15 per cent of concentrated sulphuric acid, be boiled till its color changes to a dark red, and, afterward be extracted with ether, the ether leaves on evaporation crystalline masses which on sublimation give colorless needles, which dissolved with water and treated with ferric chloride, yielded magnificent green needles having a metallic luster. This substance is hydroquinone and the yield is 46·2 per cent, the theoretical being 50.—*Ber. Berl. Chem. Ges.*, ix, 1159, Sept., 1876.

G. F. B.

6. *On Gelsemium sempervirens.*—SONNENSCHEIN has examined the root of the wild jasmine and has isolated its alkaloid, gelsemine, to which he gives the formula $C_{11}H_{19}NO_2$. The substance called by Wormley gelseminic acid, he finds to be esculin.—*Ber. Berl. Chem. Ges.*, ix, 1182, Sept, 1876. G. F. B.

7. *Kurze allgemeine Einleitung zu den aromatischen Nitro-verbindungen* von PETER TOWNSEND AUSTEN. Pamphlet, 43 pages. Leipzig: Winter, 1876.—This little work possesses a peculiar interest, as it is the attempt of an American to produce a comprehensive treatise in a foreign language and country. The manner in which Dr. Austen has treated this class of organic compounds differs greatly from the general style of monographs, and is certainly practical and original. The work is intended to afford all necessary data to those working on researches involving the nitro-compounds. The arrangement is such that the facts sought for can readily be found. The style of the book is clear and remarkably concise.

There is no doubt but that similar treatises on various other groups of organic compounds, such as the hydroxyl, amids, and many others, would enormously facilitate the labors of chemists engaged on original research.

The book is dedicated to Prof. A. W. Hofmann, of Berlin.

8. *Mariotte's Law.*—Prof. MENDELÉEFF, at the Warsaw meeting of Russian naturalists, described the results of researches he has pursued during 1875 and 1876, for the verification of Mariotte's law. His former researches had proved that the decrease of volume of the permanent gases proceeds at a slower rate than the increase of pressure exerted on them, if the pressure is less or much greater than the mean pressure of the atmosphere. The experiments of Regnault, made with air, nitrogen, etc., at pressures higher than that of the atmosphere proved, however, directly the contrary, and a series of measurements undertaken some years ago by Prof. Mendeléeff to verify those of Regnault, gave the same results. Suspecting that there might be some cause of error affecting in the same way both series of experiments, Prof. Mendeléeff and Mr. Bogussky constructed special apparatus eliminating all possible causes of errors and allowing the most perfect accuracy of measurements. With these they made a new series of researches, at pressures varying from 700 to 2,200 millimeters. These researches confirmed again the conclusions of Regnault,

showing only numerical differences in the values obtained, and proving, for instance, for the air, that its deviations from Mariotte's law are even less than appeared before. But the most important results of the researches is that the divergences from Mariotte's law shown by the air being negative at pressure above the mean atmosphere, as was observed by Regnault, proved to be positive (decrease of volume slower than the increase of pressure) at pressures below it. We must then conclude that the air experiences a change of compressibility at a certain pressure above the mean of that of the atmosphere; and this conclusion is supported by the circumstance that such a change was noticed also in the carbonic and sulphurous acid gases, but at pressures far lower than is the case for air. Only for hydrogen the divergence is of the positive kind at all pressures. Altogether we must conclude that the deviations from Mariotte's law are far more complicated than has been suspected.—*Nature*, xv, 70. E. C. P.

9. *Physical Properties of Gallium.*—M. Lecoq de Boisbaudran has recently prepared more than half a gram of pure gallium. In the liquid state this metal is of a beautiful silvery whiteness; but in crystallizing it assumes a very pronounced bluish tinge, and its luster notably diminishes. Isolated crystals may be obtained which are based octahedra. The melting point was found to be 30°·15, which was unaltered after remaining for two hours in boiling water. It was therefore certainly free from potassium. It was next kept for half an hour in nitric acid diluted with its volume of water. The loss amounted to only a fraction of a milligram, and the point of fusion remained unaltered. The calculation of M. Mendelćeff for a hypothetic substance which seems to correspond to gallium, at least in several of its properties, conducted to the number 5·9. The first measurement with 6 centigrams gave a density of 4·7 at 15°. Later observations gave the higher results of 5·5 to 6·2. Finally, a measurement with 58 centigrams gave, in two experiments, 5·90 and 5·97. The same gallium was afterwards kept during half an hour between 60° and 70° in nitric acid diluted with its volume of water, washed, pretty strongly, heated, and, finally, solidified in dry air. Its density at 24°·45 was then 5·956.—*Comptes Rendus*, lxxxiii, 611, *Phil. Mag.*, ii, 398. E. C. P.

10. *Plasticity of Ice.*—Prof. Bianconi, of Bologna, in 1871, published some experiments on the bending and torsion of bars and planks of ice (*Mem. Acad. of Bologna*, 3d ser., vol. i.) These show that ice may undergo slow changes of form without any crushing or regelation, and that notwithstanding its brittleness it possesses a slight degree of plasticity. Now Prof. Bianconi gives the results of further experiments on ice, much like those of Heim, or, yet more, those of Mr. Tresca on the puncheoning of metals. Granite pebbles and iron plates are slowly pressed into ice at the same temperatures, and not only do they penetrate into it as they would penetrate into a fluid or semi-fluid, but also the particles of ice are laterally repulsed from beneath the intruding body, and

form around it a rising fringe. Moreover, when a flat piece of iron is pressed into the ice, the fringe rising around it expands laterally upon the borders of the piece, and tends thus, as in fluids, to fill up the cavity made by the body driven in. These experiments tend thus greatly to illustrate the plasticity of ice; but it would be very desirable that Mr. Bianconi if he continues his researches, should accompany them by some measurements (as has already been done by Mr. Heim), in order to obtain numerical values of the plasticity of ice under various circumstances.—*Nature*, xv, 69; *Jour. de Phys.*, v, 317. E. C. P.

11. *Velocity of Electricity.*—Dr. SABINE has devised a method of measuring the contour of electric waves passing through telegraph lines. It is probable that in this sense alone electricity may be said to have a velocity. The early experiments on the time elapsing between starting electricity into one end of a conductor and receiving it at the other end, gave totally contradictory results. This interval would depend on the electromotive force employed, the resistance and capacity of the conductor, and the sensitiveness of the receiving instrument. It would therefore by no means be proportionate to the length. By the following method the electrical condition of any point of the line may be examined quantitatively at intervals of ·001 of a second or less after starting the electric impulse. It thus becomes possible to measure the form and speed of a wave. Suppose one end A of a conductor A B is placed to earth, and that the other B is connected with one pole of a battery whose second pole is put to earth. Then any point of the conductor as C will assume a potential which will be proportional to the resistance of A C. This potential may be measured by connecting C for an instant with a condenser or accumulator, and then discharging the latter through a delicate galvanometer. When the circuit is first closed a minute interval of time is required before C will attain its full potential measurements made of the relation of these quantities show the form of the electric wave passing the point C. The only mechanical difficulty is to construct a chronograph which will allow C to be connected with the condenser, a small but accurately determined time after A is connected with the battery. A heavy wheel of brass is set in motion by a steel spring so that it shall revolve exactly twice a second. The interval through which the spring acts being always the same, a nearly constant velocity is always imparted. The disc is divided into 500 equal parts. A movable index serves to regulate the angle through which the disk turns between the two connections to be recorded. The time of revolution of the disk was first determined by noting the figures read in succession under the film of a small telescope, when the disk was illuminated by half-second flashes of an induction coil. The force of the spring and the position of the trigger releasing it were adjusted until the right velocity was obtained. Recently a condenser was discharged through a known resistance for some interval indicated by the disk, and the time calculated

according to the leakage formula, from the initial and final readings of the galvanometer. If the two do not agree, the spring is altered until they do; but its action is found to be very constant and not to need alteration, except after taking the apparatus to pieces for alteration. Several series of experiments are given, and the results show the delicacy and accuracy of the method.—*Phil. Mag.*, ii, p. 321. E. C. P.

12. *Chemistry and Physics in America. Address before the American Chemical Society at its session on the 16th of last November, by Prof.* JOHN W. DRAPER, *its President.*—The following is the latter half of the able address of Prof. Draper, the whole of which would here be cited if space allowed. "In our own special science, chemistry, all that has been done has only served to extend the boundary of what remains. The thousands of analyses that have been made have brought us into a wilderness of results. We have not been able to rise to a point of view sufficiently high to discover what is the true place of those results in nature. We try to represent on the pages of our books and on blackboards formulas of the constitution of things, conscious all the time that these are at the best only convenient fictions, which must necessarily change as we gain a more perfect insight into that grandest of all problems, the distribution of Force in Space, and the variations to which it is liable. The geometry of chemistry is that of three dimensions, not of two. We have to consider the relation of points not situated on one plane, and hence it is necessary to employ three axes of reference; nay, even more, we cannot avoid the conception of the mathematical method of quaternions. Our inadequate information respecting the real grouping of atoms is followed as a necessary consequence by imperfection in our methods of nomenclature, the confusion in this respect becoming, as we all too well know, every day worse and worse.

And now while we have accomplished only a most imperfect examination of objects that we find on the earth, see how, on a sudden, through the vista that has been opened by the spectroscope, what a prospect lies beyond us in the heavens! I often look at the bright yellow ray emitted from the chromosphere of the sun, by that unknown element, Helium, as the astronomers have ventured to call it. It seems trembling with excitement to tell its story, and how many unseen companions it has. And if this be the case with the sun, what shall we say of the magnificent hosts of the stars? May not every one of them have special elements of its own? Is not each a chemical laboratory in itself? Look at the clusters in the sword-handle of Perseus; in Cassiopeia, a universe of stars on a ground of star dust; in Hercules, of which as astronomers say, no one can look at for the first time through a great telescope without a shout of wonder—the most superb spectacle that the eye of man can witness! Look at the double stars of which so many are now known, emitting their contrasting rays, garnet, or ruby, or emerald, or sapphire. Each is in accordance with its own special physical conditions, though all are under the same universal ordinance.

Now here a fact of surpassing importance presses itself on our attention. The movements taking place in those distant bodies are taking place under the same laws that prevail here on earth, and in our solar system. The law of gravitation, as developed by Newton, bears sway in all those distant worlds. In them bodies attract each other with forces directly as their masses and inversely as the squares of their distances. There the laws of the emission, absorption, and transmission of light are the same as they are with us. There ignited hydrogen gives forth its three rays, the same rays that it gives forth to us. In the uttermost parts of the universe the law of definite combination, the numerical law, and the multiple law, stand good. Sodium absorbs its two waves of definite refrangibility, and iron gives in the spectra its more than a hundred lines, more than a hundred silent but convincing witnesses of the uniformity of the constitution of the universe. There the number of vibrations that constitute a ray of definite refrangibility is the same we have found it to be here. In the enormous heat of those central suns the dissociation of molecules may be of a higher order than we can reach artificially, but the law under which it takes place is a continuation of the law here. There, though the weight of a given mass of matter is different from what it is with us, it is nevertheless determined by the law that determines here—the law of gravitation. There energy is indestructible, and is measured as it is measured among us, by work. Then is there any boundary that we can assign to natural law—is it not omnipresent, universal?

Perhaps there is no exaggeration in the assertion—for there seems abundant proof of its truth—that the light by which we see some of those distant orbs has crossed through such a prodigious space that millions of years have transpired during the journey. Then the phenomena it brings to us are those that were engendered in the beginning of the vast time so passed. Whatever there is that is in harmony with facts now happening here, is to us an unimpeachable evidence that the laws which were governing in those old ages have undergone no depreciation, but are active as ever until now. Then shall I exaggerate if I say that these laws are eternal in duration?

Infinite in influence, eternal in duration, what a magnificent spectacle? In the resistless energy of the motions of the universe is there not omnipotence? The Omnipotent, the Infinite, the Eternal, to what do these attributes belong? Shall a man who stands forth to vindicate the majesty of such laws be blamable in your sight? Rather shall you not with him be overwhelmed with a conception so stupendous? And yet let us not forget that these eternal laws of nature are only the passing thoughts of God.

But grand as this is, there is something still grander. There is another temple into which we have to pass, not that of the visible but that of the invisible. We must persist in the invasion we have made, in the revolution we have brought about in Physiol-

ogy. We have to determine the laws which preside in the nervous system of man, and discover the nature of the principle that animates it. Is there not something profoundly impressive in this, that the human mind can look from without upon itself, as one looks at his phantom image in a mirror, and discern its own lineaments and admire its own movements. My own thoughts have of late years been forcibly drawn to this, from a recognition that the interpretation by the mind of impressions from without takes place under mathematical laws, as for instance, that when external ethereal vibrations create in the mind a certain idea, that same idea will arise when the vibrations are doubled, or tripled, or quadrupled in frequency; but other ideas will be engendered by vibrations of an intermediate rate. Yet what these ideas will be may be predicted. It is true that this is only an optical case, but it extends the view that has been offered to us by a study of the structure of the ear. In the labyrinthine compartment of that organ the ultimate fibers of the auditory nerve are laid on the winding plane of the spiral lamina, in ever-decreasing lengths, each capable of trembling to the sound which is in unison with it —a mechanical action truly, answering to the sympathetic vibration with which the strings of a piano will respond to the corresponding notes of a flute—and these are translated by the mind into all the utterances of articulate speech, all the harmonies of music—speech that engenders new ideas within us, strains which, though they may die away in the air, live forever in the memory. The exquisite delight we experience in listening to the works of our great composers arises thus in mechanical movements, which are the issue of mathematical combinations. The unseen world is under the influence of number!

But what is number except there be one who numbers? When Pompey, in his Syrian war, broke into the holy of holies at Jerusalem, he expressed, as Tacitus tells us, his astonishment that there was no image of a Divinity within; the shrine was silent and empty. And so, though after death we may anatomize and explore the inmost recesses of the brain, the vailed Genius that once presided there has eluded us, and has not left so much as a phantom trace, a shadow of himself.

The experiments of Galvani and Volta have not yet reached their conclusion; those of Faraday and Du Bois Reymond have only yielded a preliminary suggestion as to the nervous force. Excepting the great sympathetic nerve, the nervous fibers themselves are, as is well-known, of two classes—those that gather the impressions of external things and convey them to the nerve-centers, and those that transmit the dictates of the will from within outwardly. The capabilities of one of the former—the apparatus for sight—have been greatly improved by various optical contrivances, such as microscopes and telescopes, an earnest of what may hereafter be done as respects the four other special organs of sense; and as concerns the second class, the result of mental operations, the resolves of the will, may be transmitted with greater

velocity than even in the living system itself, and that across vast terrestrial distances, or even beneath the sea. Telegraphic wires are, strictly speaking, continuations of the centrifugal nerves, and we are not without reason for believing that it is the same influence which is active in both cases.

In a scientific point of view, such improvements in the capabilities of the organs for receiving external impressions, such extensions to the distances to which the results of intellectual acts and the dictates of the will may be conveyed, constitute a true development, an evolution, none the less real though it may be of an artificial kind. If we reflect carefully on these things, bearing in mind what is now known of the course of development in the animal series, we shall not fail to remark what a singular interest gathers round these artificial developments—artificial they can scarcely be called, since they themselves have arisen interiorly. They are the result of intellectual acts. Man has been developing himself. He, so far as the earth is concerned, is becoming omnipresent. The electrical nerves of society are spread to a plexus all over Europe and America; their commissural strands run under the Atlantic and the Pacific.

In many of the addresses that have been made during the past summer, on the Centennial occasion, the shortcomings of the United States in extending the boundaries of scientific knowledge, especially in the physical and chemical departments, have been set forth. "We must acknowledge with shame our inferiority to other people," says one. "We have done nothing," says another. Well, if all this be true we ought perhaps to look to the condition of our colleges for an explanation. But we must not forget that many of these humiliating accusations are made by persons who are not of authority in the matter; who, because they are ignorant of what has been done, think that nothing has been done. They mistake what is merely a blank in their own information for a blank in reality. In their alacrity to depreciate the merit of their own country, a most unpatriotic alacrity, they would have us confess that for the last century we have been living on the reputation of Franklin and his thunder-rod.

Perhaps, then, we may without vanity recall some facts that may relieve us in a measure from the weight of this heavy accusation. We have sent out expeditions of exploration both to the Arctic and Antarctic seas. We have submitted our own coast to a hydrographic and geodesic survey, not excelled in exactness and extent by any similar works elsewhere. In the accomplishment of this we have been compelled to solve many physical problems of the greatest delicacy and highest importance, and we have done it successfully. The measuring rods with which the three great base lines of Maine, Long Island, Georgia, were determined, and their beautiful mechanical appliances, have exacted the publicly expressed admiration of some of the greatest European philosophers, and the conduct of that survey their unstinted applause. We have instituted geological surveys of many

of our States and much of our Territories, and have been rewarded not merely by manifold local benefits, but also by the higher honor of extending very greatly the boundaries of that noble science. At an enormous annual cost we have maintained a meteorological signal system, which I think is not equaled and certainly is not surpassed in the world. Should it be said that selfish interests have been mixed up with some of these undertakings, we may demand whether there was any selfishness in the survey of the Dead Sea? Was there any selfishness in that mission that a citizen of New York sent to equatorial Africa for the finding and relief of Livingstone, any in the astronomical expedition to South America, any in that to the valley of the Amazon? Was there any in the sending out of parties for the observation of the total eclipses of the sun? It was by American astronomers that the true character of his corona was first determined. Was there any in the seven expeditions that were despatched for observing the transit of Venus? Was it not here that the bi-partition of Biela's comet was first detected, here that the eighth satellite of Saturn was discovered, here that the dusky ring of that planet, which had escaped the penetrating eye of Herschel and all the great European astronomers, was first seen? Was it not by an American telescope that the companion of Sirius, the brightest star in the heavens, was revealed, and the mathematical prediction of the cause of his perturbations verified? Was it not by a Yale College professor that the showers of shooting stars were first scientifically discussed, on the occasion of the grand American display of that meteoric phenomenon in 1833? Did we not join in the investigations respecting terrestrial magnetism instituted by European governments at the suggestion of Humboldt, and contribute our quota to the results obtained? Did not the Congress of the United States vote a money grant to carry into effect the invention of the electric telegraph? Does not the published flora of the United States show that something has been done in botany? Have not very important investigations been made here on the induction of magnetism in iron, the effect of magnetic currents on one another, the translation of quantity into intensity, and the converse? Was it not here that the radiations of incandescence were first investigated, the connection of increasing temperature with increasing refrangibility shown, the distribution of light, heat, and chemical activity in the solar spectrum ascertained, and some of the fundamental facts in spectrum analysis developed long before general attention was given to that subject in Europe? Here the first photograph of the moon was taken, here the first of the diffraction spectrum was produced, here the first portraits of the human face were made—an experiment that has given rise to an important industrial art!

Of our own special science, chemistry, it may truly be affirmed that nowhere are its most advanced ideas, its new conceptions, better understood or more eagerly received. But how useless would it be for me to attempt a description in these few moments

of what Prof. Silliman, in the work to which I have already referred, found that he could not include on more than 100 closely printed pages, though he proposed merely to give the names of American chemists and the titles of their works. It would be equally useless and indeed an invidious task to offer a selection; but this may be said, that among the more prominent memoirs there are many not inferior to the foremost that the chemical literature of Europe can present. How unsatisfactory then is this brief statement I have made of what might be justly claimed for American science! Had it been ten times as long, and far more forcibly offered, it would still have fallen short of completeness. I still should have been open to the accusation of not having done justice to the subject.

Have those who gloat over the shortcomings of American science ever examined the Coast Survey Reports, those of the Naval Observatory, the Smithsonian Contributions, those of the American Association for the Advancement of Science, the Proceedings of the American Academy of Arts and Science, those of the American Philosophical Society, the Lyceum of Natural History, and our leading scientific periodicals? Have they ever looked at the numerous reports published by the authority of Congress on geographical, geological, engineering, and other subjects—reports often in imposing quartos magnificently illustrated.

Not without interest may we explore the origin of the depreciation of which we complain. In other countries it is commonly the case that each claims for itself all that it can, and often more than is its due. Each labors to bring its conspicuous men and its public acts into the most favorable point of view; each goes upon the maxim that a man is usually valued at the value he puts upon himself. But how is it with us? Can an impartial person read without pain the characters which we so often attribute to our most illustrious citizens in political, and what is worse, in social life? Can we complain if strangers accept us at our own depreciation, whether of men or things?

We need not go far to detect the origin of all this—it is in our political condition. Here wealth, power, preferment—preferment even to the highest position in the nation—are seemingly within the reach of all, and in the internecine struggle that takes place every man is occupied in pushing some other man into the background. I fear that in political life there is no remedy for this, such is the violence of the competition, so great are the prizes at stake. But in the less turbulent domain of science and letters we may hope for better things. And those who make it their practice to decry the contributions of their own country to the stock of knowledge may perhaps stand rebuked by the expressions that sometimes fall from her generous rivals. How can they read without blushing at their own conduct such declarations as that recently uttered by the great organ of English opinion, the foremost of English journals? The Times, which no one will accuse of partiality in this instance, says: "In the

natural distribution of subjects, the history of enterprise, discovery, and conquest, and the growth of republics fell to America, and she has dealt nobly with them. In the wider and multifarious provinces of art and science she runs neck and neck with the mother country and is never left behind!"

There are among us some persons who depreciate science merely through illiterate arrogance; there are some who, incited by superficiality, dislike it; there are some who regard it with an evil eye, because they think it is undermining the placid tranquillity they find in lifelong cherished opinions. There are some who hate it because they fear it, and many because they find that it is in conflict with their interests. But let us who are the servants of science, who have dedicated ourselves to her, take courage. Day by day the number of those who hold her in disfavor is diminishing. We can disregard their misrepresentations and maledictions. Mankind has made the great discovery that she is the long hoped-for civilizing agent of the world. Let us continue our labor unobtrusively, conscious of the integrity of our motives, conscious of the portentous change which is taking place in the thought of the world, conscious of the irresistible power which is behind us! Let us not return railing for railing, but above all, let us deliver unflinchingly to others the truths that Nature has delivered to us!

The book of Nature! shall not we chemists, and all our brother-students, whether they be naturalists, astronomers, mathematicians, geologists, shall we not all humbly and earnestly read it? Nature, the mother of us all, has inscribed her unfading, her eternal record on the canopy of the skies, she has put it all around us on the platform of the earth! No man can tamper with it, no man can interpolate or falsify it for his own ends. She does not command us what to do, nor order us what to think. She only invites us to look around. For those who reject her she has in reserve no revenges, no social ostracism, no *index expurgatorius*, or *auto da fé!* To those who in purity of spirit worship in her heaven-pavilioned temple, she offers her guidance to that cloudy shrine on which Truth sits enthroned, "dark with the excess of light!" Thither are repairing, not driven by tyranny, but of their own accord, increasing crowds from all countries of the earth, conscious that whatever their dissentions of opinion may heretofore have been, in her presence they will find intellectual concord and unity.

13. *Prof. Draper's researches in Physics.*—Prof. Draper's researches are a very prominent part of the scientific work of the country. We cite the following from the Address of the President of the American Academy of Arts and Sciences, in March last, on the presentation to Prof. Draper of the Rumford medals. —EDS.

In an elaborate investigation, published in 1847, Dr. Draper established experimentally the following important facts: 1. All solid substances, and probably liquids, become incandescent at the same temperature. 2. The thermometric point at which substances become red-hot is about 977° Fahr. 3. The spectrum of an incandescent solid is continuous; it contains neither bright nor dark fixed

lines. 4. From common temperatures nearly up to 977° Fahr., the rays emitted by a solid are invisible. At that temperature they are red, and the heat of the incandescing body being made continuously to increase, other rays are added, increasing in refrangibility as the temperature rises. 5. While the addition of rays, so much the more refrangible as the temperature is higher, is taking place, there is an increase in the intensity of those already existing. Thirteen years afterward Kirchhoff published his celebrated memoir on the relations between the coefficients of emission and absorption of bodies for light and heat, in which he established mathematically the same facts, and announced them as new. 6. Dr. Draper claims, and we believe with justice, to have been the first to apply the daguerreotype process to taking portraits. 7. Dr. Draper applied ruled glasses and specula to produce spectra for the study of the chemical action of light. The employment of ruled metallic specula for this purpose enabled him to avoid the absorbent action of glass and other transparent media, as well as to establish the points of maximum and minimum intensity with reference to portions of the spectrum defined by their wave lengths. He obtained also the advantage of employing a normal spectrum in place of one which is abnormally condensed at one end and expanded at the other. 8. We owe to him valuable and original researches on the nature of the rays absorbed in the growth of plants in sunlight. These researches prove that the maximum action is produced by the yellow rays, and they have been fully confirmed by more recent investigations. 9. We owe to him, further, an elaborate discussion of the chemical action of light, supported in a great measure by his own experiments, and proving conclusively, and, as we believe, for the first time, that rays of all wave-lengths are capable of producing chemical changes, and that too little account has hitherto been taken of the nature of the substance in which the decomposition is produced. 10. Finally, Dr. Draper has recently published researches on the distribution of heat in the spectrum, which are of the highest interest, and which have largely contributed to the advancement of our knowledge of the subject of radiant energy.

II. Geology and Mineralogy.

1. *Explorations made under the direction of F. V. Hayden, in* 1876.—For reasons beyond the control of the Geologist in charge, the various parties composing the United States Geological and Geographical Survey of the Territories, did not commence their field work until August. Owing to the evidence of hostility among the northern tribes of Indians it was deemed most prudent to confine the labors of the survey to the completion of the Atlas of Colorado. Therefore the work of the season of 1876 was a continuation of the labors of the three preceding years, westward, finishing the entire mountainous portion of Colorado with a belt fifteen miles in width of northern New Mexico and a belt twenty-five miles in breadth of eastern Utah. Six sheets of the Physical Atlas are now nearly ready to be issued from the press. Each sheet embraces an area of over 11,500 square miles, or a total of 70,000 square miles. The maps are constructed on a scale of four miles to one inch with contours of 200 feet, which will form the basis on which will be represented the geology, etc. The areas of exploration the last season are located in the interior of the continent, far remote from settlements and among the hostile bands of Ute Indians that attacked two of the parties the previous year.

Five parties were engaged in field duty: one for completing the primary triangulation of Colorado, three for topographical and geological work, and one for making observations in natural history.

The primary triangulation party was placed in charge of A. D. Wilson and took the field from Trinidad, the southern terminus of the Denver and Rio Grande Railway, August 18th, making the first station on Fisher's Peak. From this point the party marched by the valley of the Purgatoire, crossed the Sangre de Christo range by way of Costillia Pass, followed the west base of the range northward as far as Fort Garland, making a station on Culebra Peak. About six miles north of Fort Garland is located one of the highest and most rugged mountain peaks in the west, called Blanca Peak, the principal summit of the Sierra Blanca group. This was ascended by the party under Mr. Wilson, and found to be the highest peak in Colorado and the second peak in height in the United States. A comparison with some of the first class peaks in Colorado will show the relative heights.

Blanca Peak	above sea level,		14,464 feet.
Mt. Harvard	"	"	14,384 "
Gray's Peak	"	"	14,341 "
Mt. Lincoln	"	"	14,296 "
Mt. Wilson	"	"	14,280 "
Long's Peak	"	"	14,271 "
Uncompahgre Peak	"	"	14,235 "
Pike's Peak	"	"	14,146 "

Mr. Wilson made eleven primary stations over a large portion of Southern and Western Colorado and completed about 1,000 square miles of topography that had been omitted by one of the parties of last year.

In company with the triangulation party, Mr. Holmes made a hurried trip through Colorado, touching also portions of New Mexico and Utah. He was unable to pay much attention to detailed work, but had an excellent opportunity of taking a general view of the two great plain belts that lie, the one along the east, the other along the west base of the Rocky Mountains. For nearly 2,000 miles travel he had constantly in view the Cretaceous and Tertiary formations, among which are involved some of the most interesting geological questions. He observed among other things the great persistency of the various groups of rocks throughout the east, west and north, and especially in the west; that from Northern New Mexico to Southern Wyoming the various members of the Cretaceous lie in almost unbroken belts, while the Tertiaries are hardly less easily followed.

Between the east and the west there is only one great incongruity. Along the east base of the mountains the upper Cretaceous rocks, including Nos. 4 and 5, are almost wanting and consisting at most of a few hundred feet of shales and laminated sandstones. Along the west base this group becomes a prominent and important topographical as well as geological feature. In the southwest, where it forms the "Mesa Verde" and the cap of the Dolores plateau, it comprises upward of 2,000 feet of coal-bearing strata, chiefly sandstones, while in the north it reaches a

thickness of 3,500 feet and forms the gigantic hog-back of the Grand River valley.

While in the southwest, he visited the Sierra Abajo, a small group of mountains which lie in Eastern Utah, and found as he had previously surmised that the structure was identical with that of the four other isolated groups that lie in the same region. A mass of trachyte has been forced up through fissures in the sedimentary rocks and now rests chiefly upon the sandstones and shales of the lower Cretaceous. There is a considerable amount of arching of the sedimentary rocks, caused probably by the intrusion of wedge-like sheets of trachyte, while the broken edges of the beds are frequently bent abruptly up as if by the upward or lateral pressure of the rising mass. He was able to make many additional observations on the geology of the San Juan region, and secured much valuable material for the coloring of the final map.

He states that the northern limit of ancient cliff builders in Colorado and Eastern Utah is hardly above latitude 37° 45′.

The Grand River Division was directed by Henry Gannett, topographer, with Dr. A. C. Peale as geologist. James Stevenson, executive officer of the survey, accompanied this division for the purpose of assisting in the management of the Indians, who last year prevented the completion of the work in this locality by their hostility.

The work assigned this division consisted in part of a small area containing about 1,000 square miles lying south of the Sierra la Sal. The greater portion of the work of this division lay north of the Grand River, limited on the north by the parallel of 39° 30′ and included between the meridians of 108° 00′ and 109° 30′.

The geological work of this division, by Dr. Peale, connects directly with that done by him in 1874 and 1875. Sedimentary formations prevail in both districts visited during the past season.

The country first examined lies between the San Miguel and Dolores Rivers, extending northward and northwestward from Lone Cone Mountain. The general character of this region is that of a plateau cut by deep gorges or cañons, some of which, especially toward the north, extend from the sandstones of the Dakota group to the top of the Red Beds. The depth of the cañon however is no indication of its importance as a stream bed, for away from the main streams they are dry the greater portion of the year. There are no great disturbances of the strata, what folds do occur being broad and comparatively gentle.

The San Miguel River leaving the San Juan Mountains flows toward the northwest and, with its tributaries, cuts through the sandstones of the Dakota group, exposing the variegated beds lying beneath that have generally been referred to the Jurassic. About twenty-five or thirty miles north of Lone Cone, the river turns abruptly to the west and flows west and southwest for about fifteen miles, when it again turns and flows generally northwest until it joins the Dolores. Between the San Miguel and

Lone Cone the sandstones of the Dakota group or No. 1 Cretaceous are nearly horizontal, forming a plateau which on approaching the mountains has a capping of Cretaceous shales.

Beyond the bend, the San Miguel flows in a monoclinal valley in which the cañon walls are of the same description as in the upper part of its course. As the mouth is approached the Red Beds appear. Between this portion of the course of the San Miguel and the almost paralled course of the Dolores, which is in a similar monoclinal rift, there are two anticlinal and two synclinal valleys parallel to each other. They are all occupied by branches of the Dolores. Lower Cretaceous, Jurassic and Triassic strata outcrop and present some interesting geological details which will be fully considered in the report on the district. The Dolores river comes from a high plateau in a zigzag course, flowing sometimes with the strike and sometimes with the dip of the strata. Its general course on the western line is about northwest from which it turns to the northward and westward, finally changing to northwest again to its junction with the Grand. It is in a cañon the greater part of its course.

In the region of country north of Grand River, the geological formations extend uninterruptedly from the Red Beds exposed on Grand River to the White Tertiary cliffs forming the summit of of the "Roan Mountains" or Book Cliffs. The Grand is generally in a cañon in the Red Beds. On the north side the No. 1 Cretaceous sandstones form a hogback sloping toward the cliffs. Between the crest of this hogback and the cliffs, there is a broad valley formed by the erosion of the soft Cretaceous shales which extend to the base of the cliffs and in some places form their lower portion.

The cliffs are composed mainly of Cretaceous beds, rising one above another in steps, until an elevation of about 8,000 feet is reached. The summit is the edge of a plateau, sloping to N.N.E. This plateau is cut by the drainage flowing into the White River from the south. These streams rarely cut through the Tertiary series.

Coal of poor quality is found in the sandstones of the Dakota group and also in the sandstones above the middle Cretaceous beds. Wherever noticed it was in thin seams and of little economic importance.

The White River division was directed by G. B. Chittenden as topographer, accompained by F. M. Endlich as geologist.

The district assigned to this party as their field for exploration during the season of 1876, commenced from the eastward at longitude 107° 30′, joining on to the work previously done and extended westward 30 miles into Utah Territory. Its southern boundary was N. latitude 39° 30′, while the White River formed the northern limit. In order to complete the work to the greatest possible advantage in the shortest time that could be allowed, it was determined to make the White River Agency headquarters, and in two trips from there complete the work. About 3,800 square miles comprised the area surveyed.

According to the report of F. M. Endlich, the geology of the district is very simple though interesting. Inasmuch as but one divide of importance occurred within the district, the work was somewhat simplified. This was formed by the "Book Cliffs," between the drainage of the Grand on the south and the White on the north. Both of these rivers flow a little south of west, into the Green River which they join in Utah. From the junction of the Grand and Green downward the river is called the Great Colorado. Orographically, the region surveyed is comparatively simple. The "Book Cliffs" are the summit of a plateau about 8,000 feet above sea level, continuing unbroken over to the Green River. Toward the south these cliffs fall off very steeply, forming deep cañons that contain tributaries of the Grand River. On the north side—with the dip of the strata—the slope is more gentle, although in consequence of erosion numerous precipitous cliffs are formed. Descending in that direction the character of the country changes. Instead of an unbroken slope, we find that the plateau has been cut parallel by the White River drainage, and the long, characteristic mesas of that region testify to the action of erosion. Approaching the river, constantly descending with the slight dip of the strata, the bluffs become lower and lower. Though the creek valleys are wide and at certain seasons no doubt well watered, the vegetation is that of an arid country. Dwarf pines, piñons and sage brush abound, to the almost entire exclusion of other trees or grass. Traveling down White River this character is again found to change. A new series of bluffs, occasioned by heavy superincumbent strata, gives rise to the formation of deep cañons. For 45 miles the party followed the cañon of White River, that, no doubt, is analogous to that of Green River, and probably closely resembles that of the Colorado in its detail features. Vertical walls enclose the narrow river-bottoms, and the slopes of the higher portions are ornamented by thousands of curiously eroded rocks. Monuments of all kinds and figures that can readily be compared to those of animated beings enliven the scenery, which would otherwise be monotonous Two to three thousand feet may be stated as the height of the walls enclosing the White River.

Geologically speaking, the district was one of singular uniformity. Traveling westward, the older formations, reaching back as far as the Jurassic, were found. These were followed by Cretaceous which in turn was covered with Tertiary. About three-quarters of the region surveyed was found to contain beds belonging to this period. Owing to the lithographical character of the strata, water was a rare luxury in this region, and men and animals were frequently dependent upon springs. Farther west still, the Green River group sets in, forming those numerous cañons of which that of the White River is one.

The field work of the Yampah division, under Mr. G. R. Bechler as topographer and Dr. C. A. White as geologist, during the past season was principally confined to a district of north-

western Colorado lying between the Yampah and White Rivers, and between Green River and the subordinate range of mountains that lies west of and parallel with the Park Range. The area is embraced between parallels 39° 30′ and 40° 30′, and meridians 107° 30′ and 109° 30′.

The rocks of this district embrace all the sedimentary formations yet recognized by the investigators who have studied the region that lies between the Park Range and the Great Salt Lake, namely from the Uinta Quartzite (which underlies the Carboniferous) to the latest Tertiary, inclusive. Not only has the geographical distribution of these formations been mapped, but all the displacements of the strata have been traced and delineated. The last named investigations bring out some interesting and important facts, in relation to the orographic geology of the region, especially as regards the eastern termination of the great Uinta uplift and the blending of its vanishing primary and accessory displacements with those of the north and south range above mentioned. Much information was also obtained concerning the distribution of the local drift of that region; the extent and geological date of outflows of trap, etc.

The brackish water beds at the base of the Tertiary series, containing the characteristic fossils, were discovered in the valley of the Yampah. They are thus shown to be exactly equivalent with those now so well known, in the valley of Bitter Creek, Wyoming Territory. These last named localities were also visited at the close of the season's work, and from the strata of this horizon at Black Buttes station, three new species of *Unio* were obtained, making six clearly distinct species in all that have been obtained associated together in one stratum at that locality. They are all of either distinctively American types or closely related to species now living in American fresh waters. They represent, by their affinities, the following living species; *Unio clavus* Lamarck; *U. securis* Lea; *U. gibbosus* Barnes; *U. metanevrus* Rafinesque, and *U. complanatus* Solander. They are associated in the same stratum with species of the genera *Corbula*, *Corbicula*, *Neritina*, *Viviparus*, etc., and which stratum alternates with layers containing *Ostrea* and *Anomia*.

The close affinity of these fossil *Unios* with species now living in the Mississippi River and its tributaries, seems plainly suggestive of the fact that they represent the ancestry of the living ones. An interesting series of facts has also been collected, showing that some of the so-called American types of *Unio* were introduced in what is now the great Rocky Mountain region, as early as the Jurassic period, and that their differentiation had become great and clearly defined as early as late Cretaceous and early Tertiary times. Other observations suggest the probable lines of geographical distribution, during the late geological periods, of their evolutional descent, by one or more of which they have probably reached the Mississippi River system and culminated in the numerous and diverse forms that now exist there.

The work of the past season shows very clearly the harmonious relation of the various groups of strata over vast areas, that although there may be a thickening or a thinning out of beds at different points, they can all be correlated from the Missouri River to the Sierra Nevada Basin. The fact also that there is no physical or paleontological break in these groups over large areas, from the Cretaceous to the middle Tertiary is fully established. The transition from marine to brackish water forms of life, commences at the close of the Cretaceous epoch and, without any line of separation that can yet be detected, continues on upward until only purely fresh water forms are to be found. Dr. White, an eminent paleontologist and geologist says that the line must be drawn somewhere between the Cretaceous and Tertiary epochs, but that it will be strictly arbitrary, as there is no physical break to the summit of the Bridger group. H.

2. *Geological Survey of Kentucky.*—Chemical examination of the Ashes of the Hemp and Buckwheat Plants, with remarks on its bearing on Hemp Culture in Kentucky, by R. Peter, M.D., Chemist to the Survey. Publications of the Geological Survey of Kentucky under N. S. Shaler, Director. Part III, vol. ii. Second Series. 25 pp. 8vo. Frankfort, Kentucky.—The following remarks on hemp and the analyses are copied from pages 11 to 13 of this Report. "In order to ascertain the relative fertilizing influence of the leaves and roots, three hemp plants were collected, July 25th, 1864, in *the dry season.* These, one male and two female plants, were about six to seven feet high. The leaves, stems and roots, carefully separated and thoroughly air dried, weighed as follows:

The leaves weighed	23·916	grams,	equal to about	30·	per cent of	the whole plant.
The roots	"	7·433	"	"	9·3	"	"	"
The stems	"	48·430	"	"	60·7	"	"	"

These were separately incinerated and their ashes analyzed, with the following results:

RELATIVE ASH INGREDIENTS OF THE LEAVES, ROOTS, AND STEMS OF THE HEMP, CARBONIC ACID EXCLUDED.

	THE LEAVES.		THE STEMS.		THE ROOTS.	
	In 100 p'ts of ash.	In 100 p'ts of dried leaves.	In 100 p'ts of ash.	In 100 p'ts of dried stems.	In 100 p'ts of ash.	In 100 p'ts of dried roots.
Lime	48·819	4·992	23·371	0·949	20·368	0·713
Magnesia	5·726	·585	5·803	·194	8·297	·291
Potash	27·955	2·858	49·599	1·659	52·233	1·829
Soda	·236	·024				
Phosphoric acid	9·264	·947	13·374	·447	15·164	·531
Sulphuric acid	2·209	·226	1·215	·040	1·344	·047
Chlorine	·171	·017	·576	·019	·405	·014
Silica	5·620	·575	1·062	·035	2·189	·077
Per cent of phosphates	19·160	1·959	28·158	0·942	26·885	0·949
Per cent of ash	-------	10·225	-------	3·346	-------	3·502

By examination of the above table it is to be seen, that the leaves of the flowering hemp contain more of the essential mineral ingredients of the soil than all the other parts of the plant; constituting as they do, about 30 per cent of the whole plant in the air-dried state, and yielding 10·225 per cent of their weight of ash, the carbonic acid being excluded; while the stems and roots, which together form the remaining 70 per cent of the weight of the plant, give an average of less than 3·5 per cent of ash.

Nor is this great excess in the proportion of ash in the leaves due entirely to the influence of the greater evaporation which takes place on their surfaces, causing a deposit or incrustation of lime and magnesia salts and silica of the nature of stalagmite; for we see that while the amount of *silica* in the leaves is nearly fourteen times greater than that in the stems, and more than seven times greater than in the roots; the *lime* more than five times as great as that in the stems, and seven times more than in the roots; the *magnesia* three times more than that in the stems, and twice as much as that in the roots; the *phosphoric acid* and *phosphates* and the *alkalies* are in nearly double proportion in the leaves also, and the sulphuric acid five times greater in them than in the stems, and about four times greater than in the roots. So that while the leaves, when in their fully matured state or when they naturally fall, may possibly contain scarcely any but the less soluble salts which may be left in their tissues on the evaporation of the carbonated water which held them in solution in the sap, they contain, when in the growing, active condition, like all other green herbage, a very large proportion of salts of potash, and of all the mineral elements of plant nourishment, and hence may greatly enrich the soil on which they decay. It is obviously to the interest of the hemp farmer, therefore, so to manage as to spread them as regularly as possible over his hemp ground.

3. *The American Bison, Living and Extinct;* by J. A. Allen. Published, by permission of N. S. Shaler, Director of the Kentucky Geological Survey, as vol. iv, No. 10, of the Memoirs of the Museum of Comparative Zoology at Harvard College. Cambridge, Mass. 246 pp. 4to, with 12 plates and a colored map. (Welch, Bigelow & Co.).—This work, beautiful in typography, as well as in its illustrations, is a carefully prepared monograph of the American bisons, containing, as its first part, descriptions of the species, and, as its second, a thorough discussion of their geographical distribution. Two extinct species are recognized, *Bison latifrons* Leidy, and *B. antiquus* Leidy (= *B. crassicornis* Richardson). To the description of *Bison Americanus* the author has added much information on the habits of the species from his own observations. The fine colored map is introduced to illustrate its former and present distribution.

4. *Second Geological Survey of Pennsylvania.* Harrisburg, Pa.

(1.) Report of Progress in the Greene and Washington District of the Bituminous Coal-fields of Western Pennsylvania, by J. J.

STEVENSON. 420 pp. 8vo, with 3 sections and 2 County maps, showing the calculated local depths of the Pittsburg and W.

(2.) Report of Progress in the District of York and Adams Counties. 196 pp. 8vo, with Maps and Cross-sections showing the Iron-ore belts and individual Mines; by PERSIFOR FRAZER, Jr.

Mr. Stevenson's Report, after chapters on the physical features of the district and its Quaternary geology, describes in detail the Carboniferous strata, their nature, positions and relations, and then takes up the special geology of the several townships, giving numerous sections, and much information on the coal beds and coals. The closing chapter, on Economic Geology, contains information as to the thickness and variations of the coal beds, the composition of coals, constitution and value of the iron-ores, and on the distribution and source of the petroleum of the district. Mr. Stevenson concludes, with regard to the oil, that it has not arisen from the distillation of shales, but that "it is in the highest degree probable that the vegetable matter [that of the oil-bearing sandstone beds] instead of being converted into coal was converted into petroleum, and that the oil is indigenous to these sandstones."

The Terraces of the Ohio and Alleghany valleys are described as generally well defined. The upper is of various heights, 180, 250, and even 480 feet. From Monongahela to Pittsburg terraces are stated to be very distinct at 190 and 290 feet; while at the former place there are seven terraces at 40, 120, 190, 290, 340, 400, and 480 feet; and below Pittsburg, at Chartiers, there are six, the highest 390 feet. They indicate great height in those valleys for the Glacial flood, when water and earthy material were both, for a long period, of indefinite supply from the melting o the glacier.

Mr. Frazer treats of a belt in Eastern Pennsylvania which includes numerous limonite beds associated with granular limestone and hydromica slates, similar in character and position to those characterizing the Green Mountain region in Berkshire, Mass., and Salisbury, Connecticut, and the adjoining parts of New York, and also in Vermont. The relative position of the rocks is made a special study, and several sections presenting the author's present views on this subject are given, though with some expressions of uncertainty. The main point set forth is that the limestones and slates are not conformable—which is at variance with most (not all) of the sections observed by the writer in Berkshire. The volume also contains descriptions of some trap rocks, analyses of hydromica slates, limestones, and detailed descriptions and analyses of iron ores.

5. *On the Glacial Phenomena of North America;* by Professor OTTO TORELL, of Sweden. (Proc. Amer. Assoc., Buffalo.)—The following is a report of the paper by Professor Torell in the New York Times of August 30.—It may be assumed that the circumstances essential to the formation and movement of glaciers are these: 1. Abundance of moisture in the atmosphere; 2. A low temperature, due either to great elevations in low latitudes, or to

high latitudes with or without such elevations of land. These conditions insure such accumulations of snow above the line of perpetual frost as will sooner or later pass the line of perpetual snow and be changed to ice and water. The water becomes glacial rivers, and the ice will move as a plastic mass to a line determined by the amount of snow, on the one hand, and the climate on the other. The advancing movement of the glacier is accompanied by erosion and scratching of the rocks below and by the different kinds of moraines, as till or blue bowlder clay, and yellow unstratified masses—terminal, lateral, and superficial moraines. Simultaneous with these phenomena we have this action of the glacial river, namely, a partial denudation of the moraines, and the formation of stratified gravel, sand, and clay.

The glacial phenomena of the Glacial period were as follows: 1. The sinking of the temperature, accompanied by the formation and increase of glaciers; 2. The motion of the ice to its extreme limit; 3. The formation of moraines, of which a part were moved forward and constituted terminal moraines, while another portion was passed over by the ice, and then became bottom or ground moraines; 4. The removal by this advancing glacier of the glacial river deposits, or the covering of them by the glacier itself and its ground moraine. A geological section of the edge of the ice would then present either (*a*) preglacial beds; (*b*) stratified glacial deposits; (*c*) a ground moraine; (*d*) the ice with its terminal moraine: or (*a*) scratched rocks; (*c*) a ground moraine; (*d*) ice and terminal moraines. The first-named section is most common in the portions of Europe covered by Scandinavian erratics. The second is found generally in Scandinavia and in the United States.

The retrograde movement of a glacier during the period of melting is characterized: 1. By the formations of upper or terminal moraines, which are more or less leveled by local backward and forward movements of a glacier during successive intervals of time; 2. By stratified river deposits lying upon the unstratified yellow moraine, so that a section above the sections just described will present (*a*) preglacial beds; (*b*) stratified deposits; (*c*) till or ground moraine; (*d*) terminal moraines leveled down to great fields containing unstratified materials; (*e*) stratified beds formed by glacial rivers with gradually descending sources. The characteristics of deposits (*b*) are that only in the vicinity of high mountains they contain rounded stones, while farther away they consist of deposits of sand and clay. The characteristics of the deposits (*c*) are: A blue color, due to the seclusion from the oxidizing action of the air; compactness and hardness; rounded form of the bowlders, which are polished and scratched, and also generally brought from remote places. The characteristics of the deposits (*d*) are: A yellow and reddish color, occasioned by peroxidation of iron, comparative looseness of the mass, and greater angularity of the bowlders, which are rarely scratched, and usually belong to neighboring localities. The characteristics of the de-

posits (*e*) are: Stratification, abundance of rounded and unscratched bowlders; they generally consist of beds of gravel and sand, without clay. These phenomena are found not only in Europe wherever there are traces of the ice age, but are observable in the United States and in the region to the north of them. Each glacier has had its own limited area, and the same appears to have been the case with all the great drift deposits in North America. The greatest ice-field of Europe was that which originated in the highlands of Scandinavia, and thence extended over those portions of Northern Europe which are known to be covered by Scandinavian erratics.

By investigations extending through a long period of years, I have found that the above-mentioned glacial beds or deposits exist in all the countries above indicated. The Scandinavian glacier crossed the Baltic and German Ocean, and extended its moraines into the suburbs of London on the west, to the slopes of the Riesengebirge in the southeast, to the Tjernaye Bay, the icy, on the northeast. The presence of precisely similar phenomena in North America has established in the minds of a majority of geologists the conviction that a vast area over which such phenomena are found has also been covered with ice. But if we carefully examine this region it will readily appear that the glacial area is not continuous from ocean to ocean, but it is divisible into a northwestern area, and the Rocky Mountain area and others to the west, separated by a broad, driftless belt extending from the base of the Rocky Mountains nearly to the Mississippi, thus forcing the conclusion that the great Eastern and Western ice-fields have had different sources.

It has been the opinion of many distinguished American geologists that the source of the eastern ice-fields is to be sought in the Canadian highlands. Against this opinion several important reasons may be urged. First, in the portions of Canada in which the glaciers in question are supposed to have originated, we have reason to believe that the rocks are rounded and scratched, phenomena everywhere recognized as glacial; but I think in no case characterizing rocks known to have been covered with perpetual snow. Again, the elevation and extent of the highest portions of Canada are hardly sufficient to account for the requisite accumulation of snow and ice. And finally, so far as I have learned, there is not formed upon the rocks of the northern slope of Canada, nor yet in bowlders moved by glacial force, any satisfactory evidence that there had been a northward as well as southward movement of glaciers from the highlands of Canada. If, therefore, the phenomenon of the northern and eastern United States, usually supposed to be glacial, are indeed such, and if there is not sufficient reason for assuming the Canadian highlands to have been the source of the glaciers which produced these phenomena, then the source of them must be sought for elsewhere.

I think it will be conceded by all geologists who have studied the glacial phenomena of these regions that both the character of

the erratics and the direction of the scratches upon the rocks show that this source must lie to the northeast. Following the line of the glacial movement across Baffin's Bay and Davis' Strait to Greenland, we find that the largest body of land in the northern hemisphere, covered by ice and snow to a depth of not less than 2,000 feet, and at this moment sending down its icebergs as far as the Middle Atlantic. From the sixtieth degree of latitude to above the eightieth, this vast area of land is known to be ice-covered, and from the scarcity of the icebergs upon the eastern compared with the western coast of that land, it may be concluded that the general slope of the surface is to the southwest, and in exact direction of the glacial markings of what is known to have been the course of transported bowlders in Northeastern America. Moreover, if we bear in mind the certainty that during the Glacial period the glaciers moving from the heights of Greenland toward the sea could not have formed detached icebergs as now, but must have for the time blocked up all avenues except the one of easiest escape for the immense accumulations of ice, we may easily assume that this avenue was southwestward across British America and the northeastern part of the United States.

Finally, it may be remarked that this view is strongly confirmed by comparison of the Scandinavian with the American glacial area, for in addition to the identity of the general phenomena there is observable a marked resemblance in the proportion between the extent and other circumstances of the two areas, and that by allowing due weight to all the evidences adduced in support of the view that Greenland was the source of the glacial phenomena of the area in question, we find a probable and rational solution of a hitherto unsettled problem.

6. *Note on the Glacial era;* by JAMES D. DANA.—Professor Torell, in his important paper on the Glacial phenomena of North America, supposes that we differ in our views. It is a pleasure to know that we agree in all essential points. No American geologist holds, so far as I know, that "the source of the eastern icefields of North America is to be sought in the Canadian highlands." In my papers on this subject in this Journal for 1871 (ii, 324) and 1873 (v, 204), I was speaking of the "Glacier of New England," that is, the New England part of the great glacier; and, the conclusion arrived at was that the glacial scratches over New England, New York, and the region of Canada just north, *converge* toward an area on the Canadian watershed; and hence that the movement over New England and New York diverged from this area. I say that "the scratches of Eastern Canada, of the high land of Northern New England, of Eastern and Western New York, and of Northwestern Canada, point to a part of the Canada water-shed between the St. Lawrence Valley and Hudson Bay as the head of the glacier that moved southeastwardly over New England." I regret that my words were in any

way calculated to mislead. Professor Torell corrects the above view by making Greenland the great source; but to put Greenland in the above sentence would make it absurd, for no height of ice in that land, so far to the northeast, could have determined *southeastward movements over New England.* I did not doubt that the ice mass of the Canada water-shed, continued northward or northeastward, in the direction of the region of greatest precipitation, as the chief ice-mass of the continent; but only whether the increase of height in that direction exceeded enough that on the water-shed to cause movements in the directions indicated. I concluded that the height of the ice-surface on the water-shed would have had to have been at least 13,000 feet to have given it a slope of even fifteen feet a mile to its discharge in the ocean south and east of New England and ten feet a mile to the ice-surface over Mount Washington—the smallest pitch that seemed to be capable of producing the southward and southeastward movement; and the adding of ten feet a mile to the height farther north, thus increasing this already incredible altitude I allude to (ii, 328) but with an improbable *if.* The region of greatest height to the north of the water-shed I did not consider, because it was not within the range of my subject—the source of the "New England Glacier;" and I had no satisfactory facts as to the present amount of precipitation to the north, much less any data for judging of the hygrometric condition in the Glacial era.

In this Journal for April, 1875 (ix, 312), in citing facts from Dr. Bell, in the Report of the Canada Geological Survey for 1873-4, I observe that the facts from the vicinity of Lake Winnipeg show that a line of greatest glacier height was continued from the ice-summit on the Canada water-shed northward; but not necessarily that the height northward "was as great as over the water-shed," for "the greatest height would have been where there was the greatest amount of precipitation, supposing the melting the same." I then explain the absence of the glacier from the central regions of the continent (exclusive of the Rocky Mountains) by reference to the small amount of precipitation (referring to Schott's Rain-chart), and to the high degree of summer heat, thus making the glacier, as I state, a great coastward ice-mass, thinning out to the westward; and the Continental ice, not an ice-cap, but, as I say in a subsequent note (x, 385, 1875), an "ice-mantle thrown about the pole and descending along the borders of the Continent, especially the eastern."

6. *A monograph of American Trilobites;* by A. W. Vogdes, U. S. Army. 16 pp. Tampa, Florida.—This pamphlet is Part I of Lieut. Vogdes' monograph. It is wholly bibliographical, giving the general bibliography on the subject, from the first paper, in 1698, by Lhwyd, and then, references to the works or memoirs that treat of the several species of the genera *Asaphus, Odontopleura* (Acidaspis), *Proëtus, Bathyurus, Bathyurellus, Agraulos, Ptychoparia* (Conocephalites), and *Ceraurus.*

8. *An outline of the Geology of Canada*, based on a subdivision of the Provinces into natural areas; by E. J. CHAPMAN, Prof. Min. and Geol., University College, Toronto, Canada. 106 pp. 8vo, with several maps and plates of fossils.—Prof. Chapman's work is a brief resumé of the facts in Canadian geology, preceded by an Introduction, of 32 pages, on rock-formations and divisions of geological time. The work is a convenient one for the student and also for the geologist who would acquire a general knowledge of British-American Geology. It contains six plates of fossils representing Canadian species.

9. *Origin of Forest and Prairie regions.*—Prof. J. D. Whitney has a valuable paper on this subject in the American Naturalist for October and November.

10. *The Great Ice Age and its relations to the Antiquity of Man*, by JAMES GEIKIE, F.R.S., of H. M. Geological Survey of Scotland. 2d edit. revised. 624 pp. 8vo, with several maps and numerous illustrations. London, 1877. (Daldy, Isbister & Co.). —In this second edition, Prof. Geikie's very popular work has received various additions from recent observations, partly personal, made in Britain, and from researches in other countries, America included; and, as the author's preface states, much of it has been rewritten. The subject is well treated in all its different branches, and the illustrations are excellent. The maps include one of North America, showing the southern outline of the glacier and the general courses of erosion. Among the changes of views introduced, are the use now of the terms till and bowlder clay "as strictly synonymous;" and the adoption of the conclusion of Mr. Jamieson, that "the sea had not any share in the formation of the kames." The work is the best review of the subject to be had, and owes much of its value to Professor Geikie's own researches.

III. BOTANY AND ZOOLOGY.

1. *Date of Publication of Elliott's Botany of South Carolina and Georgia.*—The title-page of the first volume bears the date of 1821. But it is well known that the work was issued in parts, and that the publication began much earlier. The actual time of issue becomes important in respect to the priority of certain generic and specific names, notably those in Nuttall's *Genera*, published in 1818. Contrary to the testimony of the title-pages, it is generally understood that Elliott's names of *Podostigma* and *Acerates* have priority over Nuttall's *Stylandra* and *Anantherix*. To avoid future trouble it is desirable to put upon record such evidence upon the point as is now obtainable. The only printed testimony yet met with is in the *Reliquiæ Baldwinianæ*, the correspondence of Dr. Wm. Baldwin (Elliott's ablest collaborator), lovingly edited by his friend, Dr. Darlington. By reference to pp. 202, 248, 249, and 585, it is made out that the first number of Elliott's work was issued as early as October, 1816, was recalled, reprinted, and issued anew, along with the second number, before

January, 1817. The first number probably ended on p. 96; the second on p. 222. The third and fourth numbers were published before November 10, 1817. The fourth number must have included p. 466; the fifth and concluding number of the volume (to which the title-page assigns the date of 1821), must begin on or before p. 529. For, on the latter page Nuttall's genus *Diamorpha* occurs, and his work is for the first time cited; while the prefatory list of decandrous genera, on p. 466, does not contain *Diamorpha.*

This is confirmed by Elliott's correspondence with Zaccheus Collins, now in the possession of the Academy of Natural Sciences, Philadelphia, which Mr. Redfield has kindly consulted, at my request; from which it appears, in short, that No. 1 was first issued, September 26, 1816; No. 2, on or before February 19, 1817; No. 3, on or before April 3, 1817; No. 4 and No. 5, no data found; No. 6, the commencement of the second volume, appeared on or before October 12, 1821. The title page of this volume bears the date of 1824.

The collection referred to, and which contains a series of letters of Muhlenberg, Elliott, Bigelow, Torrey, and others, to Collins, has been put into excellent condition for preservation by Mr. John H. Redfield. A hasty perusal shows that it is replete with interest. It would be well if the Philadelphia Academy would print it, or at least portions of it, with some editorial notes which could now be supplied, but for which it may now ere long be too late. A. G.

2. *Homogone and Heterogone* (*or Homogonous and Heterogonous*) *Flowers.*—That difference in relative length or height of stamens and style, reciprocally, which in Torrey and Gray's Flora of North America, was very long ago designated by the term *diœcio-dimorphism*, Mr. Darwin—who detected and has made much of the meaning of the arrangement—called simply *dimorphism.* Besides these *dimorphic*, he also brought to view *trimorphic* flowers. The first name is too long for use, and carries with it some ambiguity, since it may imply a separation as well as a diversification of the sexes. Mr. Darwin's term has the disadvantage of not indicating what parts of the blossom are *dimorphic* (hermaphrodite flowers may be dimorphous in the perigonium), and a more generic name is now required, on account of *trimorphic*, etc. This has been supplied by Hildebrand, in Germany, who has introduced the term *heterostyled* and the counterpart *homostyled.* These are not particularly happy appellations; for the difference is in the stamens as well as in the pistil, and in the latter is not always restricted to the style. Well-established terms ought not to be superseded on the ground of mere improvement; but those which have not yet taken root sometimes may be. Following the analogy of *perigonium* or *perigone*, I propose the more exactly expressive term of *heterogone* (or *heterogonous*) for these flowers, such as those of *Primula*, *Houstonia*, *Lythrum*, etc. The counterpart, *homogone* (or *homogonous*) would designate the absence of this kind of differentiation. These terms, either in Latin or English

form, would work well in generic or specific characters, and have the advantage of etymological correctness. A. G.

3. *Geographical Statistics of the European Flora.*—In a paper contributed in 1874 to the Transactions of the Historic Society of Lancashire and Cheshire, Mr. Thomas Comber discussed the geographical statistics of the British flora. In another paper, read March, 1875, these enquiries are extended to the rest of the flora of Europe; and the dispersion considered with regard to latitude, station, habit of growth, character of flower, nature of fruit, seed, etc. Contrary to the common idea, the European maritime phænogamous plants appear to be less widely dispersed, on an average, than the non-maritime. Trees and shrubs range rather more widely than herbaceous plants over land, less so over sea. Plants with creeping rootstocks or stolons are much more widely dispersed than those without them. The distribution of annuals, especially of the warmer temperate species, exceeds that of perennial herbs. Endogens are more widely spread than Exogens, Apetalæ than Polypetalæ, and still more than Gamopetalæ; plants with inferior ovary are more limited than those with superior ovary; that is, the lower and less specialized in structure are more widely distributed than the higher or more specialized. That the inconspicuously colored surpass in range those with brightly colored and conspicuous flowers, may be regarded as another illustration of the same rule. The Cryptogams, of course, have much the widest range. Plants with fleshy fruit considerably surpass those with dry fruit in area of distribution, in the ratio of about 5 to 3. Of the dry fruits, the indehiscent belong to plants with a somewhat higher average of distribution. The curious conclusion, formerly reached from various data, is confirmed by the statistics of the European flora, namely, that *Compositæ* with pappus, on the average, are less widely distributed than those without; and generally, that plants with special adaptations for dispersion of fruit or seeds, are rather less widely dispersed than those which have no such special appliances; excepting, however, the coma of seeds. This, as De Candolle concludes, and Mr. Comber confirms, is accompanied by a high degree of dispersion. Much of this probably comes from the large number of *Salices* in the European flora; these being woody plants of comparatively low organization, and largely boreal. We doubt if this rule holds with *Asclepiadeæ*—the most comose-seeded of the higher orders. The species of *Asclepias* in North America are not remarkable for wide range. Although number of seeds might be supposed to give advantage, yet, on the whole, the European plants with solitary seeds have somewhat wider range than those with two or more seeds in each cell. Plants with albuminous seeds somewhat surpass in range the exalbuminous. This is remarkable in view of the fact that seeds of longest known vitality and which best endure exposure to sea water, are mainly exalbuminous or nearly so. Large genera have somewhat higher dispersion than small ones; and variable species, than those not particularly variable. The laws that govern the distribution of plants are complex and recondite. A. G.

4. *The Wild Flowers of America.* Illustrations by ISAAC SPRAGUE. Text by GEORGE L. GOODALE, M.D., Assistant Professor of Vegetable Physiology and Instructor of Botany in Harvard University. Part I. Boston: (Houghton & Co.) Dec. 1876. pp. 16, tab. 1–4, imp. 4to.—It is proposed to published this work in quarterly parts or numbers, and in it "to present illustrations and descriptions of all the more attractive flowering plants of America,"—meaning, no doubt, the United States, and the Atlantic portion of them, without excluding, perhaps, the Western and even the Pacific States as the work goes on. It is a large undertaking, even under the most restricted view. The want has been felt, and various futile attempts have been made to supply it. They have speedily come to nought, most of them deservedly, the few worth having because they would not pay. The only work of the kind we can now call to mind which gave fairly good figures of our wild flowers, and which was carried beyond a single part or volume, was by the late Dr. W. P. C. Barton. This was upon a plan not unlike that of the present work, perhaps equally expensive, for the figures were hand-colored, but far less sumptuous, and the figures—though really good—by no means so admirable as those by Mr. Sprague, who is almost unrivaled as a botanical draughtsman. These figures are not in the style of the North American Genera Illustrated, in which Mr. Sprague's talent in this line was first made known. The plates of that work were addressed to botanists only, are uncolored outlines, mainly valuable for their dissections and other details. These are imperial quarto plates, representing the flowers and as much of the herbage as is needed to give their part and bearing, in their natural colors, reproduced from the artist's paintings by the chromo-lithographic process. The undertaking was probably suggested by the success of this kind of work by the same artist in the colored plates of Mr. Emerson's Trees and Shrubs of Massachusetts, to which we called attention a year ago. The present work therefore addresses itself to amateurs as well as to botanists, to all lovers of flowers and admirers of beautiful works of art. From all these evidently it must have a large patronage if it is to prosper and continue. Nothing upon such a scale of excellence has ever been attempted in this country before. The plates are simply exquisite; in the typography the Riverside Press has done its best; and the letterpress not only describes the flowers represented clearly and popularly, but expatiates upon their arrangements for insect-aid in fertilization—the novel and attractive topic of the day—and adds other curious lore.

The first plate charmingly represents our wild Columbine (*Aquilegia Canadensis*); the second, our wild Cranesbill (*Geranium maculatum*); the third, Many-leaved Aster (*Aster undulatus*); the fourth, both the Yellow Gerardia (*G. flava*) and the commoner slender purple species, *G. tenuifolia.* (We take blame to ourselves for having given currency to "False Foxglove" as a popular name for the large yellow-flowered species of *Gerardia.* Gerardia makes a good popular name, and would soon become as

familiar as *Magnolia* or even *Lobelia*.) "The great expense attending the work requires that the price per part shall be $5.00," say the publishers. We admire their courage in the enterprise, and in aiming at the highest attainable excellence. There are indications that their laudable endeavors will be responded to, and that the time has at length arrived when a popular work of this kind and in this style—so creditable to all concerned in it—may be appreciated and sustained. A. G.

5. *Report upon Geographical and Geological Explorations and Surveys, west of the One-hundredth Meridian*, in charge of First Lieutenant GEO. M. WHEELER, under the direction of Brigadier General A. A. Humphreys, Chief of Engineers, U. S. A. Vol. V. Zoology. Washington: Government Printing Office. 4to, 1019 pp., with 45 plates.—This large and valuable volume is handsomely executed, and is in every way creditable to the officers under whose direction it has been prepared, and to the several naturalists who have contributed reports to it. The plates are well executed, and several are colored (chromolithographs.) Although this volume is dated 1875, and was doubtless then printed, it appears not to have been actually published until the latter part of the summer or early in the autumn of 1876. It includes the following reports:

Introductory Letter, by H. C. Yarrow, M.D., surgeon and naturalist to the expedition; Notes upon Geographical Distribution and Variation, by Dr. Yarrow; Report upon the collections of Mammals, by Dr. Elliott Coues and Dr. Yarrow; Report upon the Ornithological Collections, by H. W. Henshaw; Report upon the collections of Batrachians and Reptiles, by Dr. H. C. Yarrow; Synopsis of the Reptiles and Batrachians of Arizona, with critical and field notes and an extensive synonymy, by Dr. Coues; Report upon the collections of Fishes, by Prof. E. D. Cope and Dr. Yarrow; Report upon the Hymenoptera, by E. T. Cresson, with List of Formicidæ, by Edward Norton; Reports upon the Diurnal Lepidoptera, by T. L. Mead and W. H. Edwards; Report upon new species of Zygænidæ and Bombycidæ, by R. H. Stretch; Report on Diptera, by C. K. Osten-Sacken; Report upon the Coleoptera, by Henry Ulke; Report upon the Hemiptera, by P. R. Uhler; Report upon the Orthoptera, by Prof. Cyrus Thomas; Report on the Neuroptera and Pseudo-neuroptera, by H. A. Hagen; Report upon the terrestrial and fluviatile Mollusca, by Dr. Yarrow; Report upon the fresh-water Leeches, by A. E. Verrill. The plates illustrate rare or novel species and varieties of birds, reptiles, fishes, and insects. A. E. V.

IV. ASTRONOMY.

1. *The secular change of Magnetic Declination in the United States, and other parts of North America: New discussion by* CHARLES A. SCHOTT, Assistant U. S. C. S.—This is an extension of Mr. Schott's paper in the Coast Survey Report of 1859, and forms App. No. 8 of the Report for 1874. Forty-three sta-

tions are represented in the discussion, and over 400 observations. Formulæ are given for each station, with decennial tables computed therefrom. Mr. Schott says:

"A cursory examination of the column containing the epochs of greatest *easterly* excursion, the *deflecting* force producing the secular change attaining then an easterly maximum, shows that the needle became stationary in direction, and then reversed its secular motion, in the New England States toward the end of the past century, in the Atlantic coast States to the west and south early in the present, and in Mexico about the close of the first third of the present century. In California, Oregon and Washington Territory, it has not yet reached this condition. We thus have the following epochs for comparison: Halifax, about 1711; Portland, Portsmouth, Newburyport, Salem, Boston, Cambridge, Nantucket and Providence, about 1779; Hartford, New Haven, New York, Hatborough, Philadelphia, Washington and Cape Henry, about 1800; Charleston, Savannah, Key West and Havana, about 1800; New Orleans, about 1831; Vera Cruz, Mexico, Acapulco and San Blas, about 1837; San Diego, Monterey and San Francisco, expected about 1907 (yet very uncertain.)

We are thus directed to the extreme northeastern States for probable indications of what may be expected to follow on the seaboard in more southern and western States. Respecting the secular movement of the needle, apparently a little more than a century passed before the influence which produced the turning of the north end of the needle westward in Maine (increasing there the western declination), was felt in Lower California (diminishing there the eastern declination). In California, Oregon, and Washington Territory, the eastern declination is at present still *increasing*, but with a losing rate. By the time the western elongation of the secular change is reached in Maine, we may expect to see the needle in the *opposite* phase, or at its eastern elongation in California. We cannot as yet follow this influence directly over the interior of the United States for want of early observations; the westernmost interior stations for which an epoch could be made out were Buffalo, Erie, Cleveland and Detroit; these give the average turning epoch 1794. It may be quite practicable hereafter to trace out curves uniting all stations where the needle was stationary at a given epoch, and again at other epochs for regular intervals of time, say of ten or twenty-five years.

Returning to the first table, the constant in each formula would represent the normal direction of the needle about which the motion constituting the secular change would be performed in an average cycle of about two hundred and seventy years, and with extreme deflections on either side of it equal to the coefficient of the periodic term, all under the *supposition* that the law of the secular movement was truly expressed. It is no doubt much more complex, and besides may fail at any time; yet, as far as our present experience reaches, and within the interval when the first reliable observations were made to the present time, it is found trustworthy."

2. *Investigation of Corrections to Hansen's Tables of the Moon;* by S. NEWCOMB.—This memoir forms Part III of papers published by the Commission on the Transit of Venus. For determining the longitude of the Transit Stations from moon occultations it became necessary to determine the errors in the tables of the moon which 13 years' observations and the discussions of earlier data develop. It was already known that an unexplained correction to the moon's mean motion must be applied, that now amounts to about 10″. In addition to this and to several other corrections, Prof. Newcomb finds an empirical term necessary to satisfy observations, the form of which is,

$$1'',50 \text{ sin. } [g+21^\circ,6(Y-1865{\cdot}1)],$$

where g is the mean anomaly, and Y the date in years. This term is not yet explained in the theory of the moon.

3. *Knobel's Reference Catalogue of Astronomical Papers and Researches.*—We have received advance sheets of the Monthly Notices of the Royal Astronomical Society for November, 1876, which contains an important bibliographical paper by E. B. KNOBEL, F.R.A.S., with the title above. The author has selected various subjects of Stellar Astronomy, and has made nearly exhaustive indices of the various memoirs and papers relating to these published in the many astronomical and scientific periodicals and in separate treatises. The subjects chosen are: (1.) Double Stars, and the theory of Binary Systems. (2.) Variable Stars. (3.) Red Stars. (4.) Nebulæ and Clusters. (5.) Stellar proper motions. (6.) Parallax and Distance of Stars. (7.) Star Spectra. These are thoroughly and carefully indexed, Double Stars alone having over 700 references, and the rest being equally full. There are about 3,000 references in the list, and a careful examination of one section by the writer has proved its accuracy and its completeness. E. S. H.

V. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Notes on Assaying and Assay-Schemes;* by PIERRE DE PEYSTER RICKETTS, E.M., Ph.D., etc. 172 pp. 8vo. New York. 1876.—Dr. Ricketts, Instructor in Charge of the Assay Laboratory of the School of Mines, Columbia College, has embodied in this work the system of assaying practiced in the school which has been developed under Dr. Chandler and his assistants. Every such treatise is sure to add something to the common stock in its department. The notes are systematic, and the assay-schemes are clearly presented and specific. B. S.

2. *Alcoholic Strength of Australian Wines.*—From the report of a commission appointed by the Governor to inquire into the alcoholic strength of South Australian wines, and printed by authority of the House of Assembly (July, 1874) at Adelaide, it appears that the amount of glucose in the mature grapes of that province ranges from 25 to 30 per cent, and produces in the wine an alcoholic strength of from 28 to 40 per cent of proof spirit.

One sample of must, prepared March 24, 1874, from the press of Hon. Samuel Davenport, at Beaumont, gave a specific gravity at 70° F. of 1·1425, which corresponds to 28·409 grams per gallon of glucose, and 20·743 per cent of absolute alcohol, or 44·522 of proof-spirit by measure.

The average of 17 samples of must, pressed from the grapes by the two analysts, Messrs. Copins and Thomas, to avoid all chance of falsification in the hands of the vintner, gave for the specific gravity 1·1179: grape-sugar, 27·259=proof-spirit, 28·419 per cent. The maximum of sugar and proof-spirit in the 17 samples examined by these two chemists was found in the juice of the Frontignan grape grown by Mr. Gillard, at Norwood, namely—sugar, 32·165; proof-spirit, 33·505.

Mr. Francis, one of the analysts, says in his report, "the natural grape juices of this colony are capable of producing very strong wines, which are more likely to exceed 26 per cent of proof-spirit than otherwise, and that the fruit contains all the elements to set up and complete fermentation to the full conversion of the sugar into alcohol without acetification."

From the colonies of Victoria and New South Wales we have a report on the alcoholic strength of 200 samples of wine, of which 38 were from the latter colony, in Albury district; 101 from Murray district, in Victoria, and the remainder from eight other wine districts of the same colony. Messrs. Moody and Heath, government inspectors of distilleries, made the determinations. They show, for New South Wales and the Murray district, a range of proof-spirit from a minimum of 20 per cent to a maximum of 34, the greater number ranging about 28.

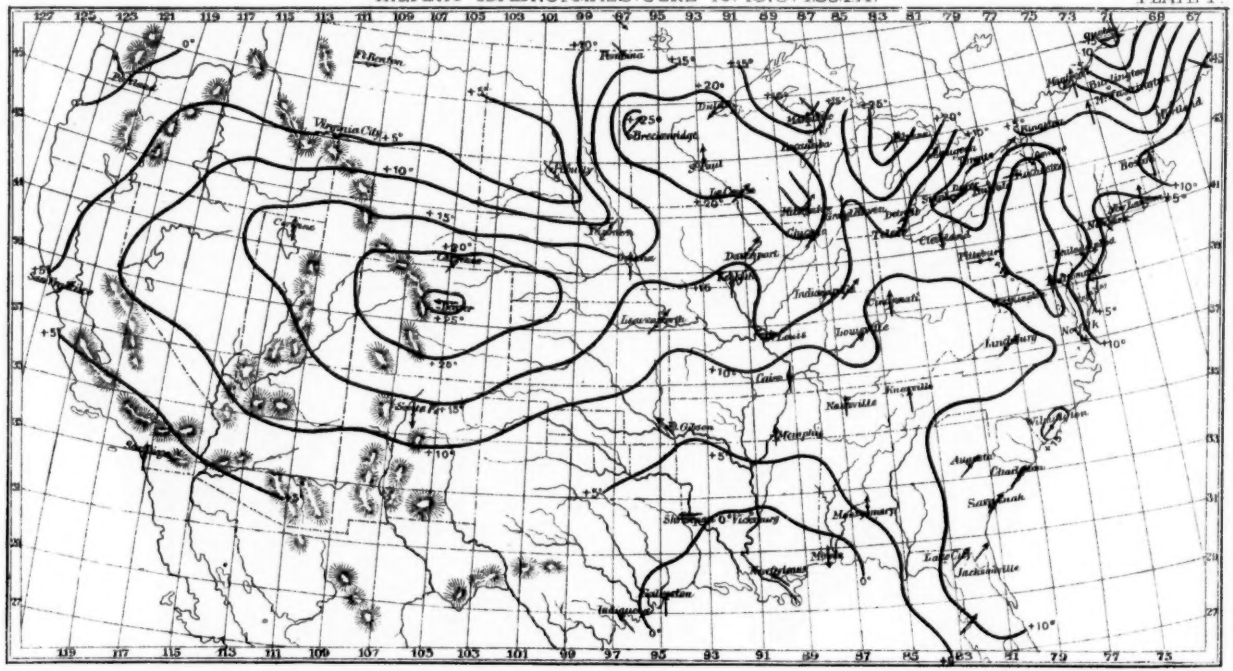
The grapes cultivated are exclusively of European origin. The soil and climate are wonderfully well adapted to the growth of abundant fruit; but as yet the qualities of bouquet and flavor, admired in the best European wines, are feebly and often not at all developed in those of Australia made from the same grapes. Nor is the *gôut de terre*—the result of a too rank soil and growth—wanting in the Australian wines. In this respect and in intoxicating power they much resemble the wines of California. B. S.

OBITUARY.

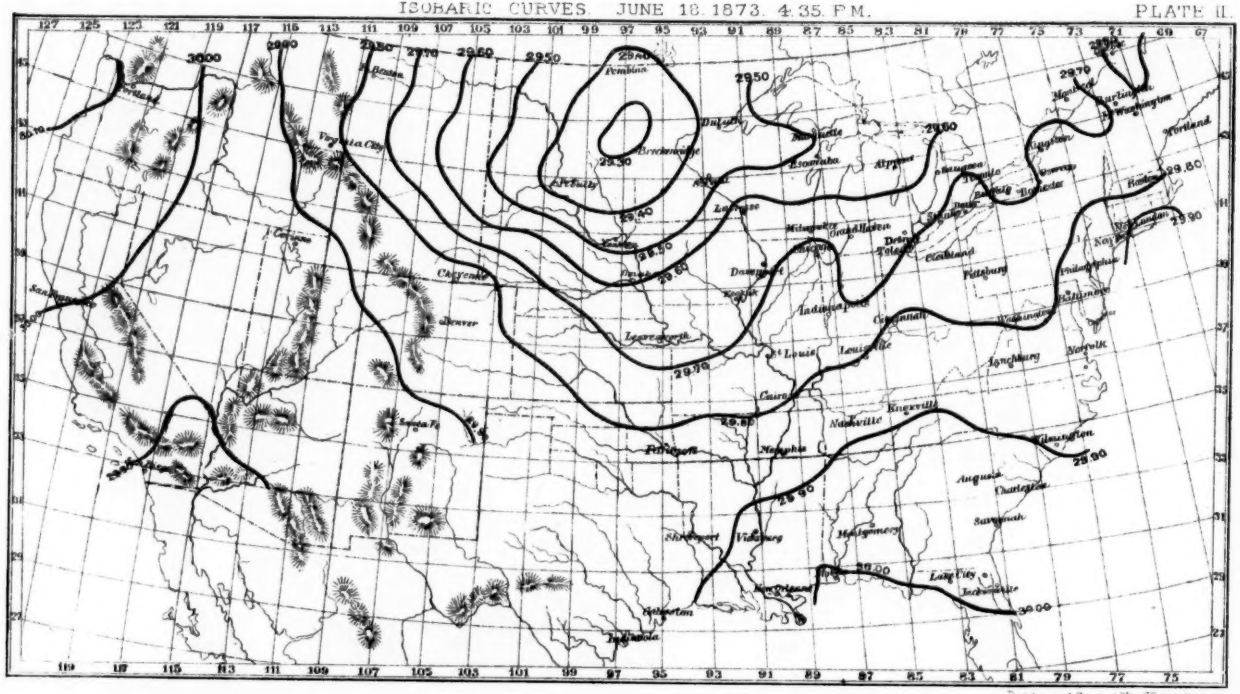
F. B. Meek, the author of various elaborate works and memoirs on American Paleontology, died on the 22nd of December. An obituary notice is deferred to the following number.

David Forbes, a learned geologist, Foreign Secretary of the Iron and Steel Institute, one of the Secretaries of the Geological Society of London, a Fellow of the Chemical and also of the Royal Society, died on the 5th of December, aged forty-eight years. He was a great traveller and resided for a while in Bolivia and Peru making researches in its mines and geology, which he afterward published.

THERMIC ISABNORMALS. JUNE 16. 1873. 4.35 P.M. PLATE I.



ISOBARIC CURVES JUNE 16. 1873. 4.35 P.M. PLATE II.

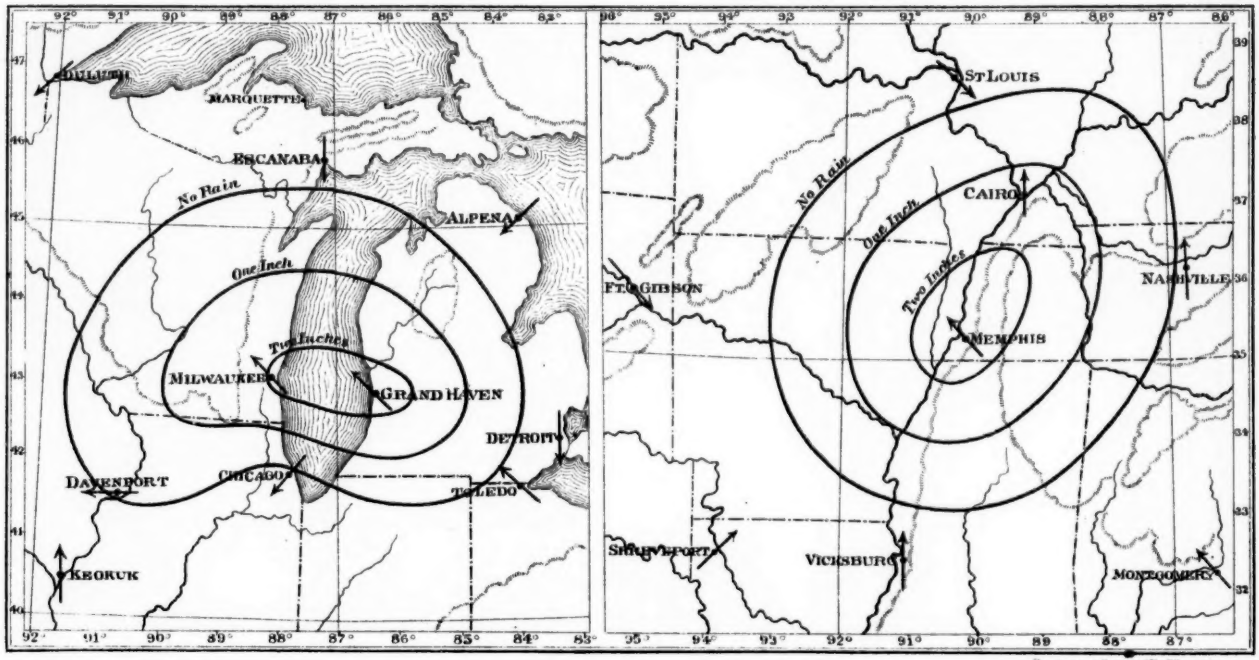


Punderson & Cozzens New Haven Conn

RAIN AREA SEPT. 23. 1872.

RAIN AREA JUNE 10. 1873.

PLATE III.



Anderson & Ormsbee, New Haven, Conn.